JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

VOL. 23 FEBRUARY, 1931 No. 2

CONTENTS

The Grounding of Telephone Cable Sheaths to Water Pipes. By Ira D. Van Giesen 149

The Significance of Waterborne Typhoid Fever Outbreaks, 1920–1930. By Abel Wolman and Arthur E. Gorman 160

Problems of St. Paul Water Supply. By Leonard N. Thompson 202

Notes on Minneapolis Water Department. By C. C. Wilbur 211

Dental Deficiencies and Drinking Water. By R. W. Kehr. 214

Reclamation of Treated Sewage. By R. F. Goudey 230

The Cost of Rendering Public Fire Protection Service. Edward B. Mayer 241

Waterworks Intakes and the Screening of Water. By John W. Cunningham 258

Observations of Water Supplies of London and Paris. By Edward Bartow 267

Softening a Well Water Supply. By N. T. Veatch, Jr., and B. L. Ulrich 272

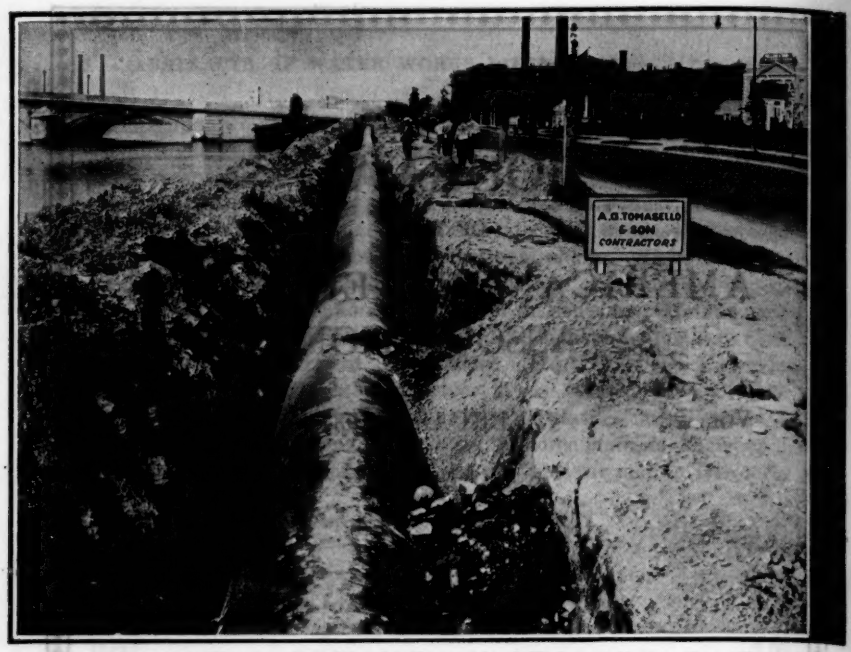
Conservation by Metering. By F. R. Vannoy 276

Projects for Standardization 280

Discussion. The Early Use of Chlorine. By William Boby 283

Society Affairs. The California Section. The Missouri Valley Section 285

Abstracts 295



Biggs 48-inch electrically welded steel pipe laid on Boston-Cambridge installation, along Memorial Drive and Charles River, near River Street Bridge. A. G. Tomasello & Son, Contractors.

Mr. Tomasello writes about Biggs Welded Steel Pipe

"You furnished approximately 4,600 feet of 60-inch, 2,000 feet of 48-inch, and 1,100 feet of 42-inch and 36-inch electrically welded steel pipe. We are very much pleased to say that during the progress of the work there were no delays caused by the delivery of the pipe, nor by any reason due to the manufacture of the pipe.

"This work was very complicated, and a great many specials were necessary, and at all times the shop drawings and the actual pipe delivered to us conformed and laid easily at a reasonably low cost.

"During the entire progress of the work we at all times were very much pleased in the way that you conducted the deliveries of the pipe, and the manner in which the pipe was delivered to us without any damage being caused in transit.

"We would be very happy to give you any other business that we may have of this nature.

Yours very truly,
A. G. TOMASELLO & SON, INC.
By Jos. A. TOMASELLO"

Biggs Electrically Welded Steel Pipe is in service on many large municipal and private works projects.

THE BIGGS BOILER WORKS COMPANY

Akron, Ohio

New York **Detroit**

JOURNAL
OF THE
AMERICAN WATER WORKS ASSOCIATION

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings
Discussion of all papers is invited

Vol. 23 FEBRUARY, 1931 No. 2

THE GROUNDING OF TELEPHONE CABLE SHEATHS TO WATER PIPES[1]

By Ira D. Van Giesen[2]

Water-works men in general prefer to prohibit all connections of any nature whatever between electrical circuits and water pipes. This attitude was made evident by the results of the questionnaire which the American Water Works Association sent out to its members. The Bureau of Water Works and Supply, at that time, went on record with a dissenting opinion, holding that any such connection to its water pipes must stand on its own merits and be determined by the engineering facts of the particular case. No general rule can be laid down to govern all such connections with any degree of fairness, or which logically can be supported by the facts involved. It is the purpose of this article to set forth the natural laws and phenomena that constitute the facts which determined our dissenting voice. Whether our conclusions are justified will be left to you, individually, to determine.

The question of whether to ground or not to ground was first brought to our attention by the local telephone company. They requested us to grant them permission to make electrical connections between the lead sheaths of their aerial cables and certain of our water services in a particular area of the City of Los Angeles.

[1] Presented before the California Section meeting, October 30, 1930.

[2] Bureau of Water Works and Supply, Department of Water and Power, Los Angeles, Calif.

These connections were for the purpose of reducing noise existing in the subscriber's telephone sets within this neighborhood, thus enabling the telephone company to render a more satisfactory and efficient service to the public.

The telephone company had made an investigation of the effects of making these connections and had furnished us the data obtained which supported the conclusion that, with proper methods of installation, no electrolysis hazard would be created by making the connections requested. We made an independent survey and obtained data agreeing with that which the telephone company had furnished us, so permission to make the particular connections requested was granted.

A public utility is an organization that performs a requested service to the public. All services which the public demands comes under the same law of necessity, and the public's servants, the various utilities, all have the same status of domestic servant within the domicile of the community. Only by coöperation, and good feeling among the servants, can the work of the household be efficiently and satisfactorily maintained. For any servant to relegate to itself a sort of major-domo position and on such assumption, to assume to merit prime consideration with the consequent attitude of superiority toward the other servants results in no unselfish consideration, blemishes the service rendered and makes impossible the highest service by the others. Whenever an opportunity arises for the Bureau of Water Works and Supply to assist any other public utility to render a higher service to the public, it does all it can to take full advantage of the opportunity.

Therefore, when the local telephone company requested us to assist them in solving their noise problem, we made a full investigation to determine if we could contribute to the bettering of their important service without lowering the efficiency of ours. We placed ourselves in the position of the telephone company and studied the problem from their viewpoint in order to determine what solution the nature of the problem dictated.

TWO TYPES OF ELECTRICAL CURRENT

There are two types of electricity used for commercial power purposes. The natures of these two types differ greatly, so that certain things can be done by the one that can not be done by the other.

These two commercial forms of electricity, it is true, have a few common characteristics, nevertheless they differ so radically that there is a world of difference in their use and their effects. These two types are direct current, commonly called, d.c., and alternating current, commonly called, a.c.

Direct current electricity flows in one direction like the water in a trunk line; alternating current flows first in one direction and then in the opposite, changing in regular intervals of time, like the flow of water in the connection to a pressure equalizing tank. In commercial alternating current the flow changes in direction 25, 50, or 60 times in one second, the flow in the pipe connection to a pressure equalizing tank changes one, two or more times in twenty-four hours. It is easy to understand that the flow of water in the equalizing tank connection can not be used for the same purposes for which the flow of water in a trunk line is used. Analogously, alternating current can not do many of the things that direct current can. Alternating current will carry and reproduce the human voice in a telephone circuit, unaltered direct current will not do this. On the other hand electroplating (which destroys the anode by electrolysis) can be done by direct current, but can not be accomplished by alternating current.

When an electric current flows along a wire, or some other conductor, the space around the conductor is in a condition of stress. This stress is dual in its nature. One part of this stress is due to the fact that the conductor is electrically charged at a given voltage. This part of the stress, called the electro-static field, will cause an induced static potential on any other conductor that runs parallel to it and this potential will have a voltage varying directly as the voltage on the first conductor and inversely as the square of the distance between them. This phenomenon is commonly called the condenser effect since the action is the same. The other part of the stress in the space around the conductor is due to the flow of current along the conductor and is magnetic in its nature. This magnetic field has a like effect on a parallel conductor, except that only as a change occurs in the current flow in the first conductor is there a voltage set up in the parallel conductor. Thus when the current on the conductor is d.c., there is a negligible condenser effect and no electro-magnetic induction except when the current in the conductor starts and stops its flow. However, when the current is a.c., the electro-magnetic induction becomes very great, while the condenser effect still remains small in comparison with the effect by induction. As stated, the

magnitude of the voltage induced longitudinally on the parallel conductor will depend on the distance between the two conductors, the current flowing in the first conductor, and the period of change of that current, i.e., the frequency.

THE EFFECTS OF DIFFERENT CYCLE FREQUENCIES

In Los Angeles, as in many other places, the several utilities have joint use of poles. Between 80 and 90 percent of the aerial telephone cables are on poles also used by the power companies to carry their power and distribution lines. This places the telephone circuits in the very position to increase induction voltages.

The fundamental frequency of the commercial power currents is generally 60 cycles per second. However, in Los Angeles there are two frequencies in use, i.e., 50 and 60 cycles. The frequency of voice currents in the telephone talking circuits ranges from about 100 to 3000 cycles per second, so that the currents set up by the voltage induced at the fundamental frequency of 50 or 60 cycles do not cause appreciable noise in the receiver of the subscriber's 'phone set. However, there are always harmonic currents in power circuits due to the characteristics of the generators, motors, and transformers in the circuits. Most of the odd harmonics are in phase and give an added effect in induced voltage along the telephone talking pairs, so that the odd number harmonics, i.e., the third, fifth, seventh, etc., cause the most noise. These harmonics in Los Angeles range from 150 up; the ones causing the most trouble lying between 150 and 800 cycles per second.

Under the operation conditions in Los Angeles, as in most cities, the solution of the problem of noise in telephone circuits reduces itself to shielding by grounding the lead sheath of aerial telephone cables. It is to be remembered that in the construction of both the power and telephone circuits all other methods of reducing induction effects are used. Most of the methods of noise reduction as applicable to the power circuits are required by law. After all these mitigation methods have been applied, in many cases, there still is too much noise current in the talking pairs and there remains but one additional means of reducing this residual noise current and that is by grounding the lead sheaths of the telephone cables. But you may say, why ground to the water pipes? Why not drive a ground rod and tie to that? The answer is that a ground rod does not do

the work, while a ground to water pipes does; the reason for this is one of resistance.

This problem of noise, arising materially from joint use, was investigated by a committee organized for this purpose, at Minneapolis. This committee rendered its report on July 15, 1926. The committee was made up of members from the American Telephone and Telegraph Company, the National Electric Light Association, the Northern States Power Company, and the Northwestern Bell Telephone Company.

The following is quoted from this report:

> Grounding the cable sheath at both ends reduces the noise by a factor ranging from 2 to 4 depending largely on the resistance of the grounds.
>
> The effect of grounding a telephone cable sheath at both ends is to reduce the longitudinal induced voltage by the shielding action of the sheath current. The amount of reduction depends upon the frequency of the induced voltage, the location and resistance of the grounds and the ratio of the resistance to the reactance of the sheath-ground loop. A relatively small amount of resistance in a ground connection on a sheath will materially impair the effectiveness of the shielding.
>
> For the commercial waveshape of power currents in Minneapolis, it was found, on the average, that receiver noise with cable sheath *suitably* grounded is reduced to about 25 to 50 percent of that with the shield isolated.
>
> A telephone conductor is said to be shielded from a power conductor by a third conductor if the current in the latter changes the field otherwise established by the power conductor. Cable pairs may be shielded by grounding the sheath, which allows current to flow over it, thereby changing the longitudinal voltage along the pairs. It also changes the potential distribution throughout the cable and consequently changes the capacity currents between the cable pairs and the earth. (The italics are mine.)

By studying the action of the currents shown in the schematic drawing, figure 1, it is possible to understand the fundamental process of shielding. You are all familiar with the effect of shielding through its application to your radio receiving set. With development of efficient shielding came the modern, quiet radio receiving set completely operated by alternating current.

In figure 1, a power line is represented which parallels a telephone talking circuit inclosed within a lead sheathed cable. The cable sheath is grounded at both the exchange and subscriber's ends. When a current I flows along the power line, it induces a current I_2 in the cable sheath which is at all times directly opposite in direction to the current flowing in the power line. Likewise the power current I also induces currents I′ and I″ in the talking pair, both of these cur-

rents flowing in a direction opposite to current I, and in the same direction as current I_2. The currents I′ and I″ are the ones that cause the noise. Now the sheath current I_2, itself induced by the current in the power line, will in turn induce current I_2' and I_2'' in the cable pair, which flowing in the opposite direction to the noise currents I′ and I″, neutralizes them and reduces the receiver noise in the subscriber's 'phone set.

At every induction there is a loss so that the currents I_2' and I_2'' are never quite as large as I′ and I″, thus there remains a residual noise current. The greater the current I_2 induced in the cable

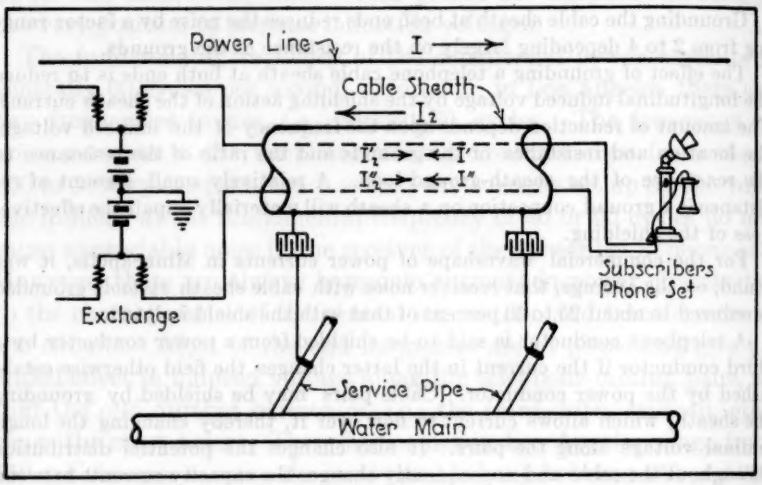


FIG. 1. SHIELDING

sheath the less the noise, so that in order to make I_2 as large as possible the resistance in the cable, sheath-ground loop must be very small.

THE EFFECTS OF VARIOUS GROUND CONNECTIONS

The effect of resistance in the ground connection is shown in figure 2. With only 2 ohms in the grounding circuit the noise is increased 20 percent over that of a dead ground. Driven ground rods have a resistance from two ohms *up to any figure*, and are not constant due to changes in the soil. Grounds to water pipes have a resistance from 0.1 ohm *down to zero*. This is the reason for grounding to water pipes.

Figure 3 shows how various grounds affect the longitudinal voltage along the cable sheath and the talking circuit. Figure 4 shows the noise units in the receiver for every millionth of an ampere (current I_2') that flows in the talking circuit. It is apparent how delicate the telephone receivers are. There is enough energy used in a common 100-watt light to cause sufficient noise in every receiver in the city of Los Angeles to make telephonic conversation difficult.

Figure 5 shows the microamperes of current in the telephone receiver for every volt of potential along the talking circuit acting on the subscriber's telephone sets.

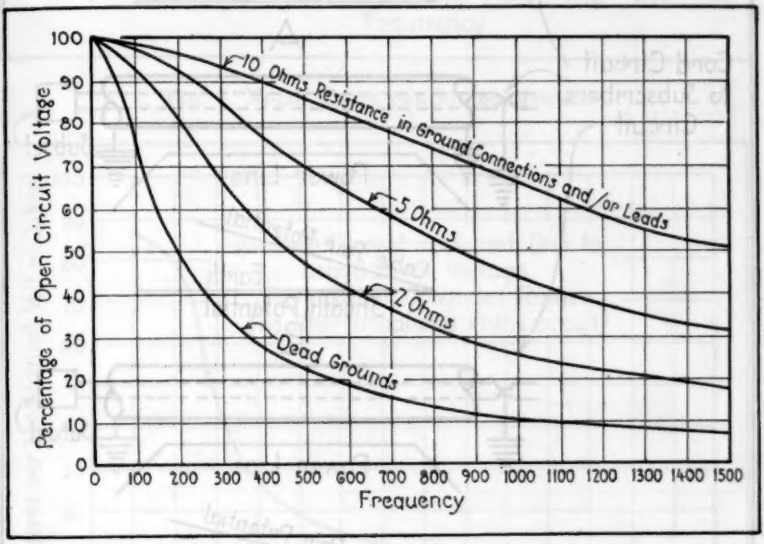


FIG. 2. REDUCTION OF LONGITUDINAL VOLTAGE ON TEST PAIR DUE TO CURRENT ALONG CABLE SHEATH CALCULATED FOR 100 PAIR CABLE FOR ½ MILE CIRCUIT

It is proposed to make the ground connection to the service pipe between the water meter and the street, using a bronze Cleverly clamp which is a bolted split clamp. The service pipe is to be cleaned and polished and a strip of sheet lead, or a few thicknesses of tinfoil, are to be wrapped around the service pipe and the clamp applied. The purpose of the sheet of lead, or the tinfoil wrapping, is to insure intimate metallic contact between all parts of the inner surface of the clamp and the service pipe. The connection wire is to be sol-

dered to the clamp, and the whole connection, clamp and all, is then to be coated with a moisture resistant, bituminous paint, wrapped

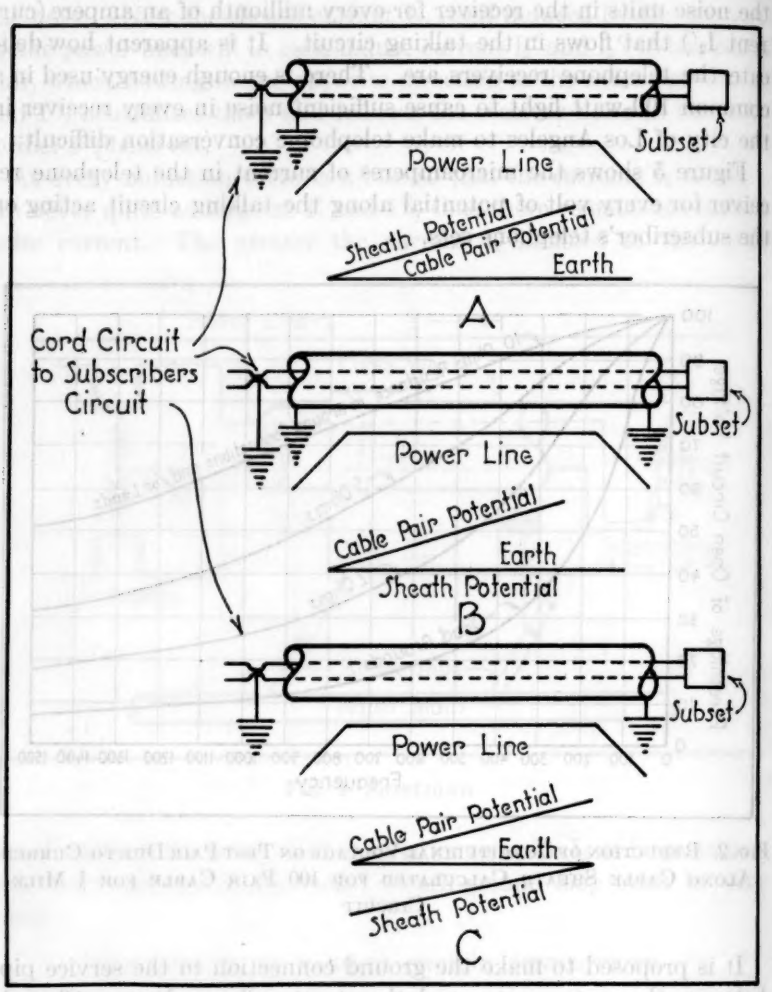


FIG. 3

with saturated strips of muslin, again painted, then wrapped, and a final coat of paint applied.

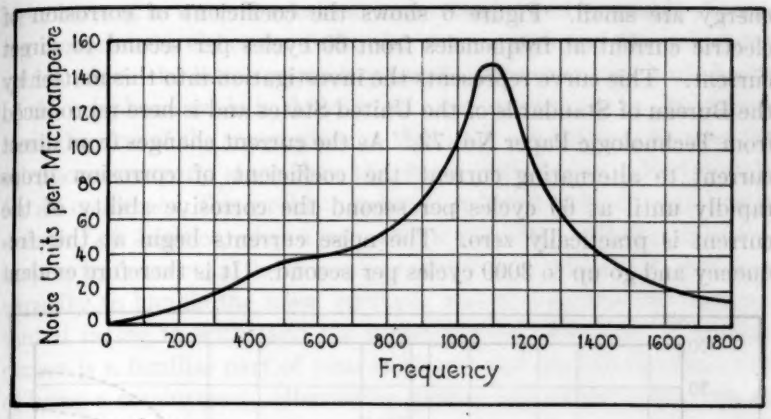


FIG. 4. NOISE UNITS PER MICROAMPERE

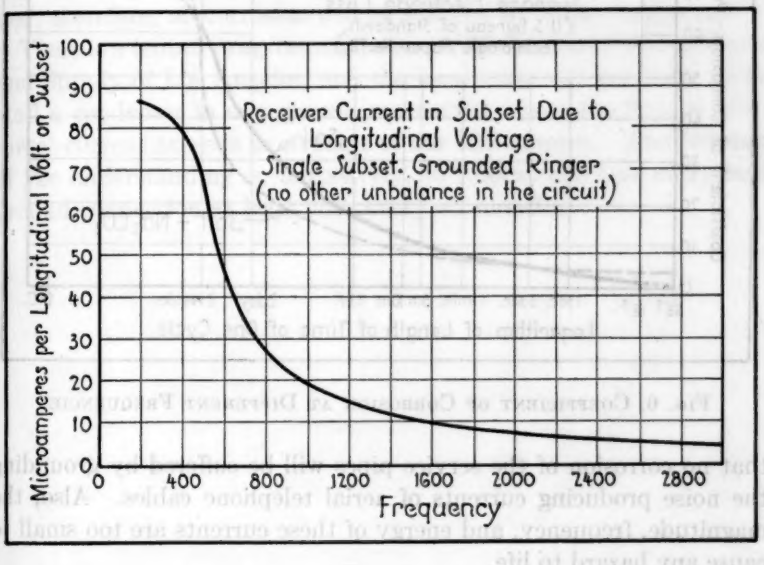


FIG. 5

EFFECT OF GROUNDING ON WATER SERVICES

What water-works men want to know is what corrosive effect will the grounding of these noise currents have on the piping system. The answer is none. The currents that cause the noise have frequencies from 50 to 3000 cycles per second, and their magnitude and

energy are small. Figure 6 shows the coefficient of corrosion of electric current at frequencies from 60 cycles per second to direct current. This curve represents the investigation into this matter by the Bureau of Standards of the United States and is here reproduced from Technologic Paper No. 72. As the current changes from direct current to alternating current the coefficient of corrosion drops rapidly until at 60 cycles per second the corrosive ability of the current is practically zero. The noise currents begin at this frequency and go up to 3000 cycles per second. It is therefore evident

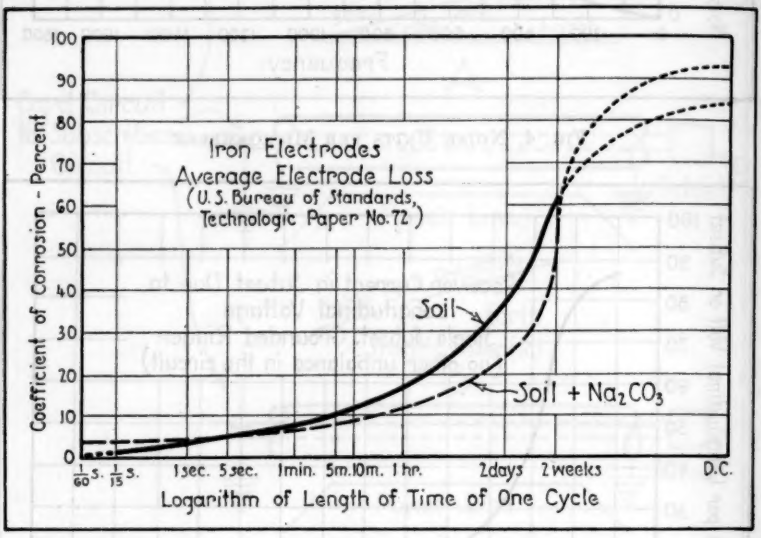


FIG. 6. COEFFICIENT OF CORROSION AT DIFFERENT FREQUENCIES

that no corrosion of the service pipes will be suffered by grounding the noise producing currents of aerial telephone cables. Also, the magnitude, frequency, and energy of these currents are too small to cause any hazard to life.

However, if the locality is served by an electric street railway with the usual track return system, there *may* exist a difference of ground potential between the two areas connected by the pipe system and the grounded aerial cable. In this case there will be an interchange of direct current from one area to the other; the current flow may be to the piping system, or to the aerial cable system depending wholly on the potenti l of the two inter-connected areas. Now this is true

stray current as water-works men understand it and is capable of causing corrosion to either, or both, the water pipes and the telephone cables where the latter go underground. However, the lead sheath of the telephone cable is three times more susceptible to electrolysis than the iron of the water pipes so that such a condition, worries the telephone company more than the water department. Fortunately for all concerned, this problem, when it is found to exist,—such as it does in Los Angeles,—has a very simple solution. All that is necessary is to connect in the grounding circuit a condenser of sufficient capacity to handle the noise currents, and of a sufficiently high potential rating to withstand the direct ground potential. The condenser is a familiar part of your radio set, and has the characteristic of being a conductor to alternating current and at the same time an open circuit to direct current. With such a condenser in the grounding circuit, no stray direct current will flow between the two systems and, therefore, no corrosion will be suffered by either company.

There is a tentative agreement between the Bureau of Water Works and Supply of Los Angeles, and the local telephone company to install a condenser in any ground connection where the flow of stray direct-current exceeds an average of one-half ampere. Another item of the understanding is, tentatively, to inspect and test every such ground connection at least once every six months.

THE SIGNIFICANCE OF WATERBORNE TYPHOID FEVER OUTBREAKS, 1920–1930[1]

By Abel Wolman[2] and Arthur E. Gorman[3]

The impressive decline in deaths from typhoid fever in North America and Europe since the beginning of the twentieth century is familiar to every health and water works official. The striking quantitative picture of this decline in the United States, for example, is indicated in the following data for the United States Registration Area:

Year	Typhoid fever deaths per 100,000
1900	35.8
1905	27.9
1910	23.5
1915	12.8
1920	7.9
1925	8.0
1928	4.9

While there is much in this statistical decrease of which to be proud, it has unfortunately in many instances created in the minds of health and water works officials and even in the general public the impression that this disease has spent its mark. As a result of this accomplishment, laxity in control measures, too often fraught with public health hazard, has become apparent. It is probably true that, as control and preventive measures in water supply are perfected, the cost of carrying on such functions may be lessened and savings from such economies may properly be diverted to other forms of public health work, but laxity in control, especially of such primary food supplies as milk and water, is frequently reflected in sudden and intense outbreaks of enteric disease. Their human and material

[1] Presented before the St. Louis Convention, June 3, 1930.

[2] Editor-in-chief, Journal American Water Works Association; Chief Engineer, Maryland Department of Health, Baltimore, Md.

[3] Wallace and Tiernan Company, Newark, New Jersey.

costs are too great penalties to pay for being asleep at the public health switch.

There should be ample warning of the importance of rigid administrative control of enteric disease in the significant fact that, in spite of the rapidly declining typhoid fever death rate on this continent and Europe, three of the largest typhoid fever epidemics on record in epidemiological history have occurred in the last decade. Pertinent data regarding them are shown in table 1.

Furthermore, the question might well be asked, if typhoid fever is fast disappearing in present and coming generations in well supervised large centers of population, will lessened immunity in the unattacked result, and will future outbreaks of this disease take a mortality toll much greater than ever before? If outbreaks of the

TABLE 1

PLACE	POPULATION	DATE	TYPHOID FEVER		SOURCE OF INFECTION
			Cases	Deaths	
Hanover, Germany	427,280	Sept.–Dec., 1926	2423	545	Water
Lyons, France, suburban area	600,000*	Nov. 1928–Feb. 1929	2143*	45*	Water
Montreal, Canada	600,000	March–July, 1927	5014	488	Milk

* Incomplete record.

intensity of those cited in table 1 can occur at this date, when the arts of water purification and dairy sanitation have reached a high degree of development, obviously something must be wrong with the control measures. The possibility of reduced immunity, coupled with the disconcerting actuality of recent epidemics, makes an analysis of recent typhoid fever incidence of special value.

The control, of course, of future typhoid is a responsibility of the health officer, for in a large percentage of cases he has the necessary police power to support his proposals. He can insist upon the elimination of potentially dangerous conditions and upon the exercise of the necessary precautionary control measures to provide against emergencies, which might be anticipated, provided reasonable inspection is maintained and recognized standards of performance are enforced.

What the weaknesses in the administrative prevention of typhoid fever incidence have been in the last ten years, it has been the aim of the present writers to uncover, insofar as they apply to those cases of waterborne origin.

In order to obtain the facts concerning such waterborne outbreaks in Canada and the United States and their relationship to the elements over which public health and water works officials have jurisdiction and control, a careful study has been made of the outbreaks which have occurred during the last decade.

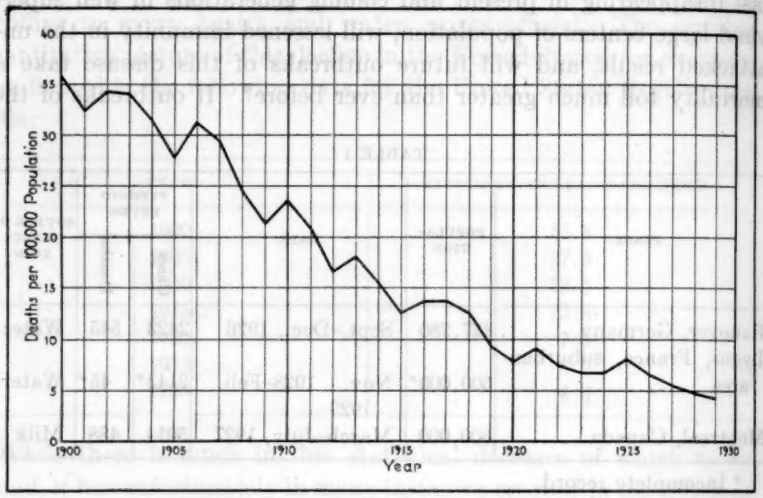


FIG. 1. TYPHOID FEVER DEATH RATE IN THE UNITED STATES REGISTRATION AREA

(From the United States Census Bureau Reports, 1900 to 1929, inclusive)

The present decade opened with a rate of 35.8 and showed a steady decline to 4.9 per 100,000 in 1928, with the exception of the year 1925. For this year nearly one-third of the states reported increases in their typhoid death rates. The general picture for the United States Registration Area is shown in figure 1.

The decade 1920–1929 was selected as representing a period in which completely adequate purification of water supplies was possible and proper protection of these supplies against the hazards reasonably and practicably susceptible to control was feasible. The information was obtained from the various state and provincial health departments, whose courteous coöperation is herewith acknowledged with

unusual pleasure. These reports were studied, particularly with reference to identifying the causes of outbreaks and determining therefrom where control measures had failed or were most needed. Reports were received from 47 states in the United States and 6 provinces in Canada. The United States reports represent 98.65

TABLE 2

YEAR	OUTBREAKS	TYPHOID FEVER		DYSENTERY CASES	TOTAL PERSONS AFFECTED—TYPHOID AND DYSENTERY CASES
		Cases	Deaths		
United States					
1920	26	2003	133	8112	10115
1921	29	550	30	2899	3449
1922	20	563	60	800	1363
1923	24	1168	119	320	1488
1924	23	1039	70	10611	11650
1925	24	1359	16	4714	6073
1926	21	849	42	45143	45992
1927	30	486	51	1208	1694
1928	19	502	33	2883	3385
1929	26	848	76	7655	8503
Total.....	242	9367	630	84345	93712
Canada					
1920	4	327	2		327
1921	4	149	11		149
1922	4	111	0		111
1923	10	1366	95		1366
1924	5	170	14		170
1925	1	32	4		32
1926	0	0	0		0
1927	4	311	6		311
1928	2	79	0		79
1929	6	291	13		291
Total.....	40	2836	145		2836

and the Canadian 79.5 percent of the population of these countries. The only state not reporting was South Carolina. The investigation brought forth the facts summarized in table 2.

The number of outbreaks in the United States shows a distinct increase for the year 1927 rising from 21 in 1926 to 31 in 1927 and

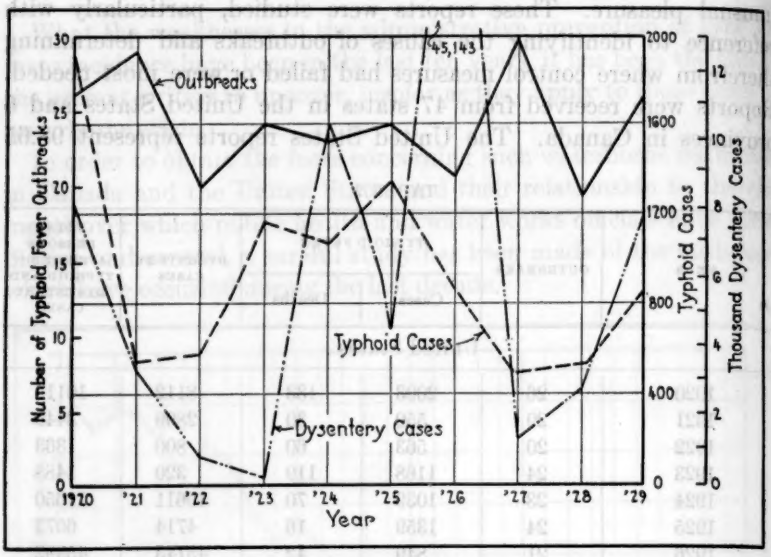


FIG. 2. WATER BORNE OUTBREAKS IN UNITED STATES, 1920–1929, INCLUSIVE

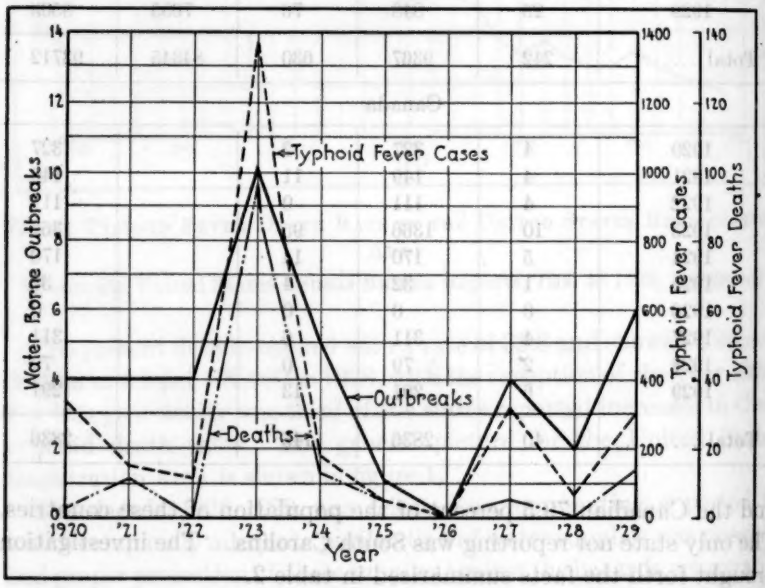


FIG. 3. WATER BORNE OUTBREAKS IN CANADA, 1920–1929, INCLUSIVE

dropping again to 19 in 1928. This was the year of heavy floods, especially in the Mississippi River valley. These high waters affected water supplies in many states. In Canada, 1923 was the high year for water borne outbreaks, with 1926 the low. In both the United States and Canada the number of outbreaks in 1929 increased over previous years. The greatest number of deaths from typhoid fever occurred for the United Staes in 1920 and for Canada in 1923,

TABLE 3

Outbreaks of waterborne diseases in the United States and Canada, classified as to population groups affected, decade 1920–29

POPULATION	NUMBER OF OUTBREAKS	PER CENT OF OUTBREAKS
United States		
1,000 and under	68	28.1
1,000 to 5,000	89	36.8
5,000 to 10,000	30	12.4
10,000 to 25,000	29	12.0
25,000 to 50,000	11	4.6
50,000 to 100,000	6	2.5
100,000 to 500,000	7	2.8
500,000 to 1,000,000	0	0.0
Over 1,000,000	2	0.8
	242	100.0
Canada		
1,000 and under	6	15.0
1,000 to 5,000	25	62.5
5,000 to 10,000	4	10.0
10,000 to 25,000	5	12.5
	40	100.0

reflecting the well-known water borne epidemics at Salem, Ohio, and Cochrane, Ontario, respectively. (See figures 2 and 3.)

Classification of the 282 outbreaks into population groups, in table 3, indicates, as might be expected, that the larger number occurred in the small cities (see figure 4), since the proportionate number of small cities is greater in both the United States and Canada.

Of the outbreaks in the United States 64.9 and of those in Canada 77.5 percent were in cities having a population of under 5000. In

both countries this appears to be the group needing the greatest attention and supervision. In the United States, 4 of the 10 largest typhoid outbreaks and 5 of the 10 largest dysentery outbreaks of the decade, occurred in cities of this group. In Canada, 8 of the largest typhoid outbreaks were in cities of this group. These facts indicate a distinct need for better supervision over water supplies of the small and moderately small towns.

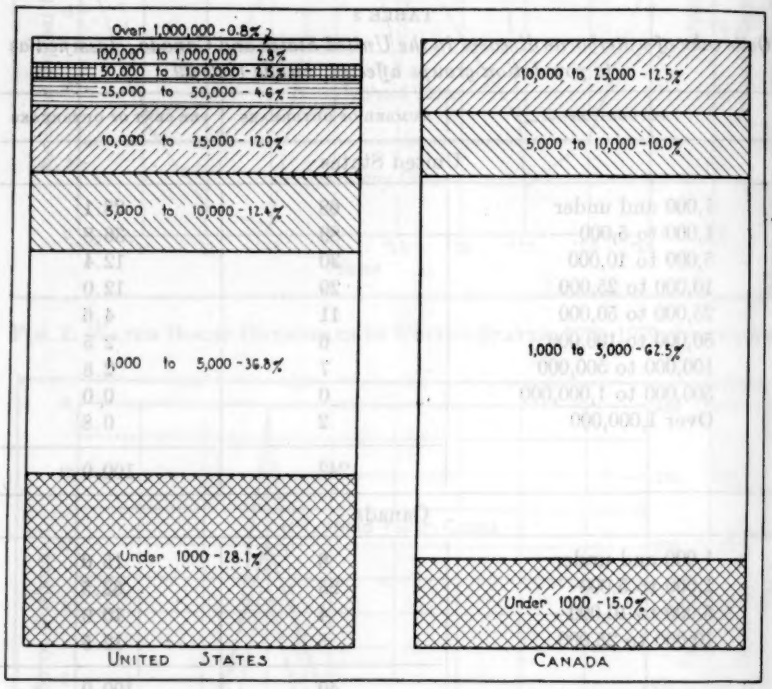


FIG. 4. PERCENTAGE DISTRIBUTION OF WATER BORNE OUTBREAKS IN THE UNITED STATES AND CANADA, 1920–1929 INCLUSIVE
(Classified as to population)

While we emphasize the need for better control in the smaller towns we should note, however, that two serious outbreaks occurred in cities having a population of over one million, where it may be presumed adequate finances were available to provide strict supervision over the quality of the public water supply.

MAJOR CAUSES OF OUTBREAKS

For the purpose of this study the causes of outbreaks were classified into seven major groups, each with minor subdivisions, making a total of twenty-six causes. Of these seven major classifications six relate to points in the water works system from the source of supply to the consumer's tap. The seventh includes a miscellaneous group not readily classified elsewhere. The descriptions of these classes are

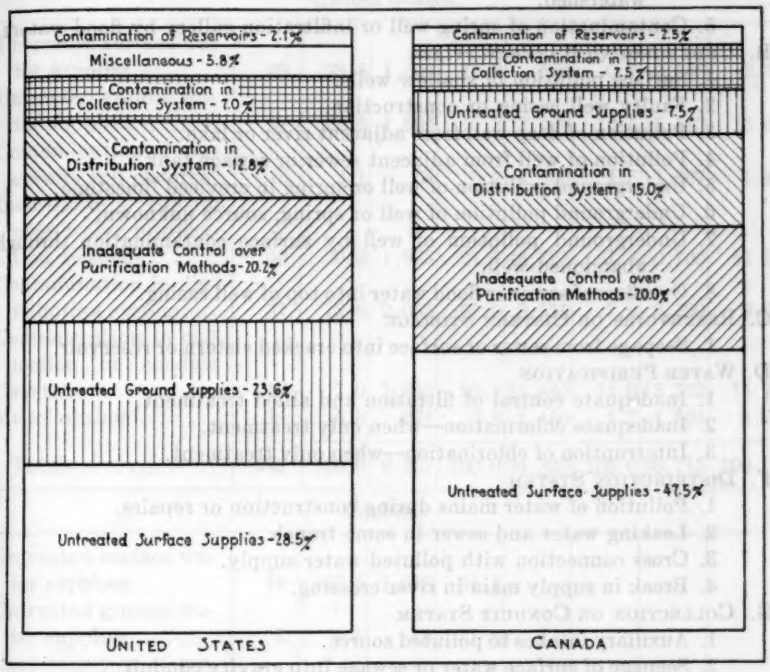

Contamination of Reservoirs - 2.1%
Miscellaneous - 5.8%
Contamination in Collection System - 7.0%
Contamination in Distribution System - 12.8%
Inadequate Control over Purification Methods - 20.2%
Untreated Ground Supplies - 23.6%
Untreated Surface Supplies - 28.5%
UNITED STATES
Contamination of Reservoirs - 2.5%
Contamination in Collection System - 7.5%
Untreated Ground Supplies - 7.5%
Contamination in Distribution System - 15.0%
Inadequate Control over Purification Methods - 20.0%
Untreated Surface Supplies - 47.5%
CANADA

FIG. 5. PERCENTAGE DISTRIBUTION OF WATER BORNE OUTBREAKS IN THE UNITED STATES AND CANADA, 1920–1929, INCLUSIVE
(Classified as to point of pollution in water systems)

presented in table 4, while the analyses of the epidemics allocated to these classifications are shown in table 5.

The largest number of outbreaks in both the United States and Canada was due to the use of untreated surface water supplies. This is to be expected if one bears in mind the widespread pollution of surface water in these countries. In the United States the second largest number of outbreaks, 57, was caused by the use of untreated

TABLE 4

Basis of classification of causes for waterborne typhoid fever for the United States and Canada during the decade 1920–29 inclusive

A. Surface Water Supplies
1. Contamination of brook or stream by pollution on watershed.
2. Use of polluted river water—untreated.
3. Use of polluted lake water—untreated.
4. Contamination of spring well or infiltration gallery by pollution on watershed.
5. Contamination of spring well or infiltration gallery by flood waters.

B. Underground Water Supplies
1. Surface pollution of shallow wells.
2. Faulty well casing or construction.
3. Pollution of deep well from adjacent river or lake.
4. Pollution of well from adjacent sewer or sewage tank.
5. Underground pollution of well or spring in creviced limestone.
6. Underground pollution of well or spring, source unknown.
7. Underground pollution of well by surface contamination through abandoned well.
8. Overflow of sewer or flood water into top of well casing.

C. Reservoirs or Cistern Storage
1. Seepage from sewer or surface into cracked cistern or reservoir.

D. Water Purification
1. Inadequate control of filtration and allied treatment.
2. Inadequate chlorination—when only treatment.
3. Interruption of chlorination—when only treatment.

F. Distribution System
1. Pollution of water mains during construction or repairs.
2. Leaking water and sewer in same trench.
3. Cross connection with polluted water supply.
4. Break in supply main in river crossing.

G. Collection or Conduit System
1. Auxiliary intakes to polluted source.
2. Seepage of surface water or sewage into gravity conduit.

H. Miscellaneous
1. Use of polluted private supply because of objectionable taste or quality of public supply.
2. Use of polluted water not intended for drinking purposes.
3. Cause of outbreak undetermined.
4. Data insufficient for classification.

ground water. In a majority of these, 30, the sources were shallow wells polluted from surface sources. (See figure 5.)

It is worthy of note that, although the use of untreated surface and well water was responsible for 52.1 and 55 percent of the outbreaks in

TABLE 5

Classification of waterborne outbreaks in the United States and Canada, 1920–1929, inclusive; as to point of pollution in water works system (see table 4)

CLASSIFICATION	OUTBREAKS		TYPHOID FEVER		DYSENTERY		TYPHOID AND DYSENTERY	
	Number	Per cent	Cases	Per cent	Cases	Per cent	Cases	Per cent
United States								
Untreated surface water supplies	69	28.5	1,506	16.0	590	0.7	2,156	2.3
Untreated ground water supplies	57	23.6	1,606	17.3	13,936	16.5	15,542	16.6
Contamination of reservoirs and cisterns	5	2.1	68	0.7	1,269	1.5	1,337	1.4
Inadequate control over water purification methods	49	20.2	1,975	21.1	48,725	57.8	50,700	54.1
Contamination in distribution system	31	12.8	2,055	21.9	6,535	7.8	8,590	9.2
Contamination in collection or conduit system	17	7.0	1,883	20.1	11,840	14.0	13,723	14.7
Miscellaneous	14	5.8	274	2.9	1,450	1.7	1,664	1.7
Totals	242	100.0	9,367	100.0	84,345	100.0	93,712	100.0
Canada								
Untreated surface water supplies	19	47.5	1,818	64.1				
Untreated ground water supplies	3	7.5	45	1.6				
Contamination of reservoirs and cisterns	1	2.5	42	1.5				
Inadequate control over water purification methods	8	20.0	433	15.3				
Contamination in distribution system	6	15.0	214	7.5				
Contamination in collection or conduit system	3	7.5	284	10.0				
Totals	40	100.0	2,836	100.0				

the United States and Canada respectively, the percentage of total typhoid fever cases in Canada due to the use of raw water, was almost twice that in the United States—viz., 64.1 to 33.3. The use of untreated surface waters was the outstanding single cause of typhoid fever in Canada during this decade. (See figure 6.)

One of the most significant findings in this study is the fact that, in the United States and to a lesser degree in Canada, *waterborne out-*

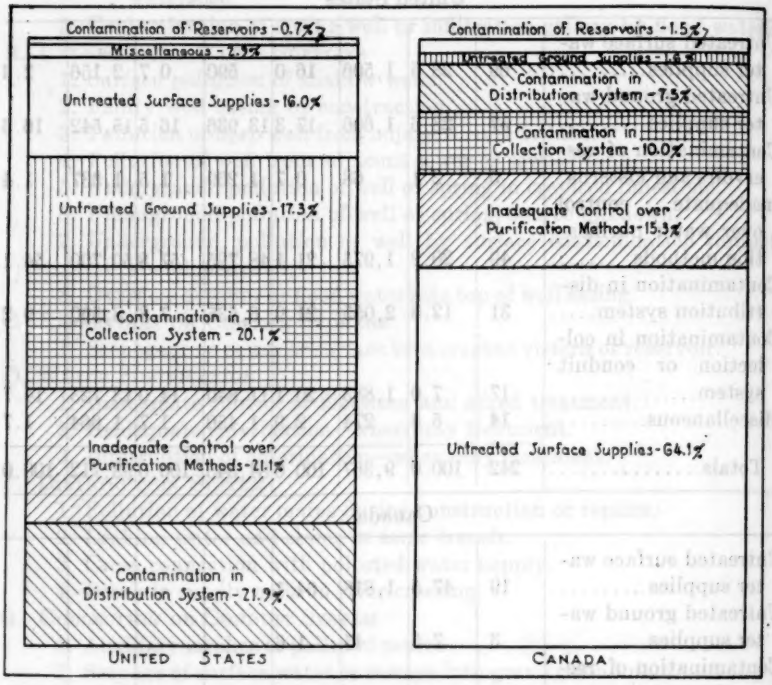

Contamination of Reservoirs - 0.7%
Miscellaneous - 2.3%
Untreated Surface Supplies - 16.0%
Untreated Ground Supplies - 17.3%
Contamination in Collection System - 20.1%
Inadequate Control over Purification Methods - 21.1%
Contamination in Distribution System - 21.9%
UNITED STATES
Contamination of Reservoirs - 1.5%
Untreated Ground Supplies - 1.6%
Contamination in Distribution System - 7.5%
Contamination in Collection System - 10.0%
Inadequate Control over Purification Methods - 15.3%
Untreated Surface Supplies - 64.1%
CANADA

FIG. 6. PERCENTAGE DISTRIBUTION OF TYPHOID FEVER CASES IN THE UNITED STATES AND CANADA, 1920–1929, INCLUSIVE
(Classified as to point of pollution in water system)

breaks during the past decade have been due as much to laxity in handling water from its source to the consumer as to the use of water from polluted sources. Certainly no stronger indictment of our methods of supervision and control is necessary to focus serious attention on this problem by health and water works officials. In the United States, excluding the 14 outbreaks for which the cause is unknown, the records show that 102 of a total of 228 outbreaks, or 44.7 percent,

were due to contamination occurring in the collection, delivery, storage or laxity in treatment. For Canada this percentage is 40.5.

The indications are that, in a high percentage of these cases, outbreaks could have been prevented by adequate inspection and control measures. Perhaps the most obvious case reported is that of one of America's largest cities, Detroit, where, in spite of the fact that the city was equipped with one of the most modern rapid sand filtration plants, in February, 1926, an outbreak of waterborne dysentery occurred accounting for at least 45,000 to 50,000 cases.

The following extract from a letter to one of the authors by Health Commissioner Henry F. Vaughan, of Detroit, narrates the important facts concerning this outbreak:

"On Thursday morning, February 25, 1926, a severe storm occurred accompanied by heavy rainfall which from all indications caused a pollution of the Detroit City water supply. The records at the filter plant showed that the turbidity began to increase at 11 a.m. reaching a maximum of 160 and dropping off suddenly between 11 and 12 p.m. The wind was from the southwest blowing directly up river, and had a maximum velocity of 55 miles per hour with attending rainfall of $\frac{3}{4}$ of an inch causing flood discharge at the Connors Creek sewer which empties above and on the opposite side of the river from the water works intake.

"At this time and for some days thereafter, samples from points throughout the distribution system gave B. coli confirmations as high as 100 per 100 cc. It was estimated at the time that 45,000 to 50,000 persons were affected with severe cases of dysentery and that one-quarter to one-third of the entire population suffered in a more or less degree from the effects of this pollution."

A balanced picture of the situation cannot, however, be obtained from a study of the number of outbreaks. Let us analyze the data by persons affected as indicated in the cases of typhoid and dysentery reported. Of the typhoid cases, 43.7 percent, and, of the dysentery cases, 66.1 percent were due primarily not to the use of polluted water at its source, but to laxity in source treatment or in faulty distribution methods. (See figure 7.)

It is, of course, a recognized fact that the use of surface or ground waters subject to pollution and without adequate purification treatment is an invitation to waterborne outbreaks. But when water is known to be polluted and necessary purification devices have been provided, is it not a serious reflection on both the water works and health officials procedures that outbreaks of typhoid fever and dysentery should occur? Two thousand and fifty-five cases of typhoid

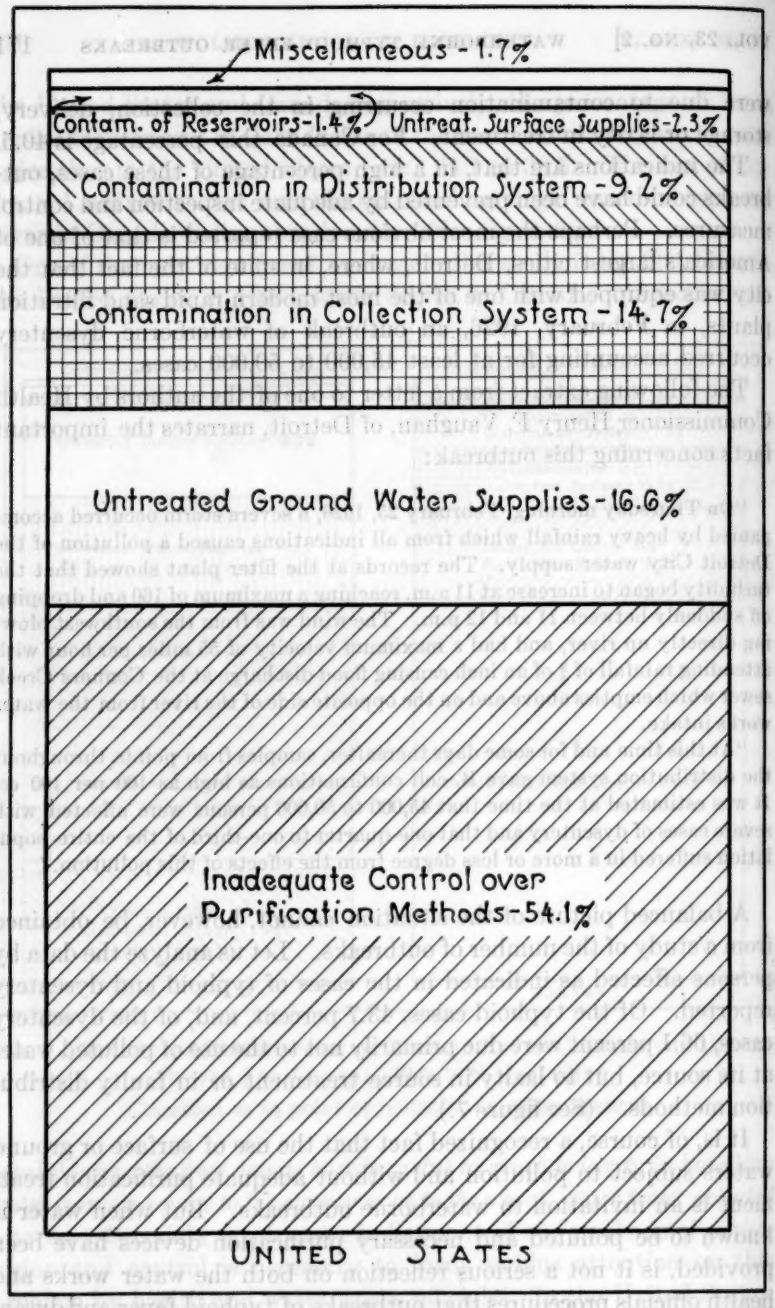

Miscellaneous - 1.7%
Contam. of Reservoirs-1.4%
Untreat. Surface Supplies-2.3%
Contamination in Distribution System - 9.2%
Contamination in Collection System - 14.7%
Untreated Ground Water Supplies - 16.6%
Inadequate Control over Purification Methods - 54.1%
UNITED STATES

FIG. 7. PERCENTAGE DISTRIBUTION OF COMBINED CASES OF DYSENTERY AND TYPHOID FEVER IN THE UNITED STATES, 1920–1929, INCLUSIVE
(Classified as to point of pollution in water works system)

fever in the United States occurred because of pollution of an apparently safe water as it was being distributed to the consumer. Of these 1995, or over 95 percent, were due to unprotected cross connections with polluted water supplies. Among these were the disastrous outbreaks at Winona Lake and Fort Wayne, Indiana, and Bloomington, Illinois.

Inadequate control over purification methods accounted for 1925 cases. Of these 395 were cases where treatment consisted of filtration and chlorination—a combination amply capable of giving protection against heavily polluted water if efficiently operated. Inadequate chlorination, where this treatment was the sole health protection, was responsible for 985 cases. This clearly indicates lack of proper control measures. Among these outbreaks were those at Newport and Covington, Kentucky; Akron, New York; Delaware, Ohio; and Salt Lake City, Utah. In the residual chlorine test, plant operators have at their command an effective method of controlling chlorination to give complete public health protection. *With proper control measures of simple character all of these cases could have been prevented.*

Seventeen outbreaks in the United States representing 594 cases of typhoid fever were due to interruption in chlorination, where this was the only safeguard against contamination. In six instances, the chlorinator was out of order and in the others it had been shut down. Pittsburg, California; Alpena, Michigan and Greeneville, Tennessee, were the outstanding outbreaks of this group. The reliance on one chlorinator, where chlorination is the sole line of defense against a potentially dangerous water supply, has always been considered a serious error, but the shut-down of chlorination under these circumstances is little short of criminal negligence.

The number of typhoid fever and dysentery cases resulting from contamination in the system for collection and transmission of raw water was high in both the United States and Canada. Auxiliary intakes were responsible for 4 outbreaks in the United States, representing 2300 dysentery cases and 69 typhoid cases. Sewage pollution of gravity conduits or breaks in section lines caused 13 outbreaks, 9540 cases of dysentery and 1814 cases of typhoid fever. The use of vitrified tile pipe for gravity transmission of water took a heavy toll. This group included the classic Salem, Ohio, epidemic, the Brigham, Utah, typhoid outbreak, and the Greenville, Illinois, dysentery outbreak. Breaks in suction lines were responsible for two outbreaks

at Grand Forks, North Dakota and the well-known Olean, New York, epidemic. In Canada, three outbreaks were due to the use of auxiliary intakes and one, the well-known Kingsville typhoid outbreak was due to a break in the intake pipe.

TABLE 6

Relative magnitude of waterborne outbreaks in the United States, 1920–29 inclusive

RANK	CLASS	NUMBER OF OUTBREAKS	TYPHOID FEVER		DYSENTERY		TOTAL TYPHOID AND DYSENTERY CASES	
			Rank	Number of cases	Rank	Number of cases	Rank	Persons affected
1	B 1	30	4	660	6	2,005	5	2,665
2	F 3	29	1	1,995	4	6,535	4	8,530
3	A 2	21	10	340	14	185	14	525
4	A 1	21	6	510	17	0	15	510
5	D 3	17	5	595	15	32	11	626
6	D 1	17	8	396	1	47,311	1	47,707
7	A 4	16	7	454	16	5	16	459
8	D 2	15	3	985	7	1,382	7	2,367
9	G 2	13	2	1,814	3	9,540	2	11,354
10	B 5	10	11	289	9	1,089	8	1,378
11	A 5	7	13	123	12	400	13	523
12	H 3	5	19	60	10	600	10	660
13	H 4	5	20	54	11	500	12	554
14	C 1	5	18	68	8	1,269	9	1,337
15	B 8	5	9	381	2	10,650	3	11,031
16	B 2	4	23	20	13	192	17	212
17	A 3	4	14	79	17	0	20	79
18	G 1	4	17	69	5	2,300	6	2,369
19	B 6	3	12	133	17	0	18	133
20	B 7	3	21	50	17	0	23	50
21	B 4	2	15	73	17	0	21	73
22	H 1	2	14	90	17	0	19	90
23	H 2	2	16	70	13	350	22	70
24	F 1	1	24	13	17	0	25	13
25	F 2	1	22	47	17	0	24	47
26	B 3	0	25	0	17	0	26	0
Total....		242		9,367		84,345		93,712

The contamination of water in storage in reservoirs and cistern caused 5 outbreaks in the United States and 3 in Canada. Four of the United States outbreaks caused 1269 cases of dysentery. The

largest one was at Marseilles, Illinois, where leakage from a polluted stream adjacent to a storage reservoir caused 700 cases; a second at Canton, Missouri, resulted in 500 cases of dysentery, 42 cases of typhoid fever and 3 deaths.

RELATIVE MAGNITUDE OF WATERBORNE OUTBREAKS AND THEIR CONTRIBUTING CAUSES

To permit the study of the relative importance of various contributing causes of waterborne outbreaks by the number of occurrence

TABLE 6A

Relative magnitude of waterborne outbreaks in Canada, 1920–29 inclusive

RANK	CLASS	NUMBER OF OUTBREAKS	TYPHOID FEVER		TOTAL TYPHOID AND DYSENTARY CASES	
			Rank	Number of cases	Rank	Deaths
1	A 2	10	2	590	3	13
2	A 1	6	4	285	4	11
3	D 2	4	7	113	5	9
4	F 3	4	6	166	6	8
5	A 3	3	1	943	1	70
6	B 1	2	14	20	11	1
7	D 1	2	10	32	8	4
8	D 3	2	3	288	2	20
9	G 1	2	5	228	10	2
10	B 5	1	12	25		
11	C 1	1	9	42		
12	F 1	1	11	27	9	2
13	F 4	1	13	21		
14	G 2	1	8	56	7	5
Total.....		40		2,836		145

and by the cases of typhoid fever and dysentery resulting, this information has been arranged statistically in tables 6 and 7.

Although the greatest number of outbreaks in the United States was due to drinking water from shallow wells, unprotected cross connections and inadequate control over purification methods account for the largest numbers of cases of typhoid fever and dysentery, respectively. The public health importance of unprotected cross connections is further emphasized by the fact that this cause rated second in responsibility for total outbreaks and fourth for dysentery cases. From these figures the unprotected cross-connection may

TABLE 7

Recapitulation of ten principal causes of waterborne outbreaks, decade 1920–29

OUTBREAKS			CASES OF TYPHOID FEVER			CASES OF DYSENTERY			PERSONS AFFECTED		
Rank	Cause	Number	Rank	Cause	Number	Rank	Cause	Number	Rank	Cause	Number
United States											
1	B 1	30	1	F 3	1,995	1	D 1	47,311	1	D 1	47,707
2	F 3	29	2	G 2	1,814	2	B 8	10,650	2	G 2	11,354
3	A 2	21	3	D 2	985	3	G 2	9,540	3	B 8	11,031
4	A 1	19	4	B 1	660	4	F 3	6,535	4	F 3	8,530
5	D 3	17	5	D 3	595	5	G 1	2,300	5	B 1	2,665
6	D 1	17	6	A 1	510	6	B 1	2,005	6	G 1	2,369
7	A 4	16	7	A 4	454	7	D 2	1,382	7	D 2	2,367
8	D 2	15	8	D 1	396	8	C 1	1,269	8	B 5	1,378
9	G 2	13	9	B 8	381	9	B 5	1,089	9	C 1	1,337
10	B 5	10	10	A 4	340	10	H 3	600	10	H 3	660
		186			8,130			82,681			89,398
% total = $\frac{186}{242}$ = 76.9			% total = $\frac{8,130}{9,367}$ = 96.9			% total = $\frac{82,681}{84,345}$ = 98.2			% total = $\frac{89,398}{93,712}$ = 95.4		
Canada											
1	A 2	10	1	A 3	943						
2	A 1	6	2	A 2	590						
3	D 2	4	3	D 3	288						
4	F 3	4	4	A 1	285						
5	A 3	3	5	G 1	228						
6	B 1	2	6	F 3	166						
7	D 1	2	7	D 2	113						
8	D 3	2	8	G 2	56						
9	G 1	2	9	C 1	42						
10	B 5	1	10	D 2	32						
		36			2,743						
% total = $\frac{36}{40}$ = 90			% total = $\frac{2,743}{2,836}$ = 96.8								

well be classed as the outstanding public health danger in water works operations.

Considering the number of persons affected, failures in purification

methods lead the list. But in using the figure of 47,707 persons affected, it must be remembered that 45,000 of these were cases of dysentery in one outbreak in Detroit in 1926. Second in importance, insofar as total number of persons affected, is water in transmission through tile gravity conduits. This is a dangerous practise and its discontinuance should be demanded by both water works and health officials. The unprotected cross connection hazard comes third in order of persons affected and the use of water from shallow wells is fourth in the same scale.

In Canada, polluted surface waters, inadequate control over purification methods and unprotected cross connections are the most important factors requiring the attention of health and water works officials.

Of the 47 states from which reports were received, 9 report no waterborne outbreaks. This does not mean that there was no typhoid fever in these states during this decade, but that there were no recorded outbreaks of magnitude in a single locality for the decade. These states are:

Arkansas	Florida
Colorado	Louisiana
Connecticut	Massachusetts
Delaware	New Hampshire
	Nevada

Wyoming reports 609 cases and 139 deaths from typhoid fever for the decade. They were not classified as to cause and, therefore, could not be included in this statistical summary. It is reported that practically all of these cases were waterborne and occurred in Big Horn County due to drinking water from the Shoshoni River, on the water shed of which an increasing number of tourists reside during the summer months.

THE LARGEST WATERBORNE OUTBREAKS

In tables 8 and 9 statistics are given concerning the twenty-five largest water borne typhoid fever and dysentery outbreaks of the decade in the United States and the ten largest for Canada. It is interesting to note that eight of the typhoid outbreaks in the United States and three of those in Canada had 200 cases or more.

Each country had an epidemic of about 1000 cases. The Winona Lake, Indiana, outbreak was due to a cross connection with the water supply at a religious camp meeting place. The State Board of

Health reports that practically all of the victims were out of town visitors, the outbreak affecting citizens in a large number of states. The reported cases of 1000 probably do not include all the cases, although the extent of this outbreak was thoroughly investigated.

TABLE 8

Twenty-five largest reported typhoid waterborne outbreaks in United States during the decade 1920–29 inclusive, in order of magnitude

TOWN	STATE	MONTH	YEAR	POPULATION	CASES	DEATHS
Winona Lake	Indiana	July	1925		1,000	?
Salem	Ohio	Aug.–Jan.	1920–21	10,305	884	27
Santa Ana	California	Jan.–Feb.	1924	30,000	369	28
Akron	New York	Aug.–Nov.	1926	2,100	284	18
Olean	New York	Sept.–Oct.	1928	21,400	245	15
Brigham City	Utah	July–Sept.	1923	4,200	230	15
Helena	Montana	Sept.	1929	12,000	205	17
Bloomington	Illinois	Jan.	1920	28,725	200	24
Chicago	Illinois	Nov.	1923	2,701,705	150	15
Pittsburg	California	May–June	1920	4,700	144	2
Salt Lake City	Utah	Sept.–Oct.	1924	131,590	144	12
Fort Wayne	Indiana	Nov.–Dec.	1923	90,000	140	24
Grafton	West Virginia	Dec.	1927	10,000	125	20
Alpina	Michigan	Mar.–May	1920	11,101	118	11
Albany	New York	April	1924	117,800	114	14
Franklin Boro	New Jersey	Nov.	1922	4,000	114	18
Covington, Newport	Kentucky	Feb.	1923	60,000	100	15
Seneca Falls	New York	Mar.–Sept.	1920	7,000	100	6
Mechanicville	New York	Jan.–Oct.	1920	8,900	96	10
"N"	Pennsylvania		1924	644	90	
Gouverneur	New York	Sept.–Oct.	1921	4,140	85	4
Coalwood-Caretta	West Virginia		1929	400	85	6
Winston	Missouri	May	1929	339	82	3
Herington	Kansas	July–Aug–	1923	4,010	79	7
Assumption	Illinois	July	1927	1,852	78	
Totals.....					5,261	311

Per cent of all typhoid $= \frac{5,261}{9,287} = 56.6$. Per cent of all deaths $= \frac{311}{614} = 50.6$

The Cochrane, Ontario, typhoid fever outbreak, with 935 cases and 70 deaths, was one of the most severe waterborne outbreaks in Canada's history. It was caused by sewage entering a lake from

which the city water supply was obtained, owing to a change in water level of an adjacent lake into which the city discharged its sewage. Considering the fact that the population of Cochrane at the time was only 3500, this is one of the most severe outbreaks on record.

The Salem, Ohio, typhoid outbreak, as well as the one at Santa Ana, California, were bitter lessons in public health control. The former was caused by sewage entering a break in a gravity conduit; the latter by sewage backing up in a drain from an air lift well allowing pollution to enter the top of the well.

Ten dysentery outbreaks included 1000 or more cases. The reporting of dysentery cases in connection with other typhoid outbreaks is

TABLE 8A

The largest typhoid fever outbreaks in Canada during decade 1920–29 inclusive

TOWN	PROVINCE	MONTH	YEAR	POPULATION	CASES	DEATHS
Cochrane	Ontario	Spring	1923	3,500	935	70
Pt. Gatineau	Quebec	Aug.	1929	2,000	200	9
St. Leonards	New Brunswick		1927	1,200	200	
Terrebanne	Quebec	Mar.	1920	2,000	160	
St. Jerome	Quebec	Nov.	1923	8,000	115	4
Bathhurst	New Brunswick		1920	1,500	115	
Edmundston	New Brunswick		1923	5,000	100	
Lachine	Quebec	Feb.–Mar.	1924	15,000	88	11
Pottam Twshp.	Quebec	Apr.	1923	350	87	9
Buckingham	Quebec	Jan.	1928	3,800	65	
Totals.....					2,065	103

Per cent of all typhoid $= \frac{2,065}{2,836} = 73.0$. Per cent of all deaths $= \frac{103}{145} = 71.0$

obviously far from complete. No dysentery cases were reported in the Canada statistics.

Both the Salem and Santa Ana outbreaks were accompanied by large numbers of dysentery, 7000 and 10,000 respectively. The Detroit outbreak previously described leads the dysentery list in the United States with 45,000 to 50,000 cases.

OUTBREAKS DUE TO UNUSUAL CIRCUMSTANCES

A number of the outbreaks reported were of unusual interest. Some of them are cited below for the lessons they teach to health and water works officials:

Springfield, Ohio, 1928. The source of supply for water at the Ohio Steel foundry, employing about 1500 persons, was a deep well in limestone. This water had been used for years and was apparently satisfactory. In August, following an extended period of wet weather, it suddenly became polluted causing 37 cases of typhoid fever from which 4 deaths resulted.

TABLE 9

Twenty-five largest reported dysentery outbreaks in United States, during the decade 1920–29 inclusive, in order of magnitude

TOWN	STATE	MONTH	YEAR	POPULATION	CASES
Detroit	Michigan	Feb.	1926	1,300,000	45,000
Santa Ana	California	Jan.–Feb.	1924	30,000	10,000
Salem	Ohio	Aug.–Jan.	1920–21	10,305	7,000
Fort Wayne	Indiana	Mar.	1929	100,000	5,000
Hillsboro	Ohio	Jan.	1921	4,356	2,000
Ozark Beach	Missouri	July	1928–29		2,000
Charlestown	Illinois	Nov.	1925	6,615	2,000
Greenville	Illinois	Jan.	1925	3,091	2,000
Riverside	Illinois	Sept.	1929	2,532	1,000
Bloomington	Illinois	Jan.	1920	28,725	1,000
Marsellies	Illinois	Jan.	1928	3,391	700
Garrett	Indiana	Nov.	1925	5,000	600
Oswego	New York	Dec.–Jan.	1928	22,369	500
Canton	Mississippi	Jan.	1922	3,000	500
"B"	Pennsylvania		1921	17,466	500
Yorkville	Illinois	Oct.	1928	441	400
Delaware	Ohio	Sept.–Dec.	1921	8,756	373
Covington, Newport	Kentucky	Feb.	1923	60,000	300
Packing Plant So. St. Paul	Minnesota	June	1929	2,700	300
"A"	Tennessee	Jan.	1928	1,500	300
Grand Forks	N. Dakota	Jan.	1928	14,010	300
Shirley	Indiana	Mar.	1927	1,200	250
No. Judson	Indiana	Sept.	1927	1,200	200
So. Pasadena	California	Apr.	1924	4,000	200
"A"	Pennsylvania		1922	1,943	200
Williamson	West Virginia	July 6	1924	7,000	111
Total					82,734

$$\text{Per cent of all dysentery} = \frac{82,734}{83,995} = 98.6$$

Use of polluted water because of disagreeable taste in public supply

Coalwood—Caretta, West Virginia, 1929. The unsatisfactory taste in the public well supply caused many citizens to resort to polluted springs and surface water, resulting in 85 cases of typhoid fever.

San Juan County, New Mexico. In order to get soft water the residents of this county frequently fill their cisterns from polluted irrigation ditches. This practise over a period of ten years was the cause of 152 cases of typhoid fever and 15 deaths.

TABLE 10

Classification of waterborne outbreaks in Canada, decade 1920–29 inclusive, outbreaks

PROVINCE	A1	A2	A3	B1	B5	C1	D1	D2	D3	F1	F3	F4	G1	G2	TOTALS
Alberta	Report no typhoid outbreaks														
British Columbia	Report no typhoid outbreaks														
Manitoba	No report received														
New Brunswick	3	2	...	...	...	...	...	...	...	...	...	...	...	...	5
Nova Scotia	No report received														
Ontario	1	...	3	2	1	1	1	4	...	...	2	1	...	1	17
Prince Edw. Island	No report received														
Quebec	2	8	...	...	...	...	1	...	2	1	2	...	2	...	18
Saskatchewan	Report no typhoid														
Yukon	No report received														
N. W. Territories	No report received														
Totals	6	10	3	2	1	1	2	4	2	1	4	1	2	1	40
Group totals	19			3		1	8			6			3		40
Order	2	1	5	6	10	10	6	3	6	10	3	10	6	10	

Herington, Kansas, 1922–1923. Because of an objectionable mineral taste in the public water supply of this city, citizens resorted to a spring in a public park for water. As a result there was in the summer of 1923 an outbreak of 19 cases of typhoid fever and 7 deaths.

In 1922 while National guard troops were on strike duty in this city, there was a sharp outbreak of dysentery among the soldiers. On investigation the State Health Department found this spring to be grossly polluted. The supply was condemned at the time and the city notified of the danger of allowing water to be obtained from this

TABLE 11

Annual distribution of waterborne outbreaks in Canada, decade 1920–29 inclusive; typhoid cases, deaths, dysentery cases

	1920			1921			1922			1923			1924			1925			1926			1927			1928			1929			TOTALS
	Typhoid	Deaths	Dysentery	Typhoid	Deaths	Dysentery	Typhoid	Deaths	Dysentery	Typhoid	Deaths	Dysentery	Typhoid	Deaths	Dysentery	Typhoid	Deaths	Dysentery	Typhoid	Deaths	Dysentery	Typhoid	Deaths	Dysentery	Typhoid	Deaths	Dysentery	Typhoid	Deaths	Dysentery	
Alberta	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
British Columbia	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Manitoba	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
New Brunswick	115	..	..	..	..	..	..	..	..	124	..	..	..	..	..	..	..	..	..	..	..	243	..	..	..	..	..	..	..	..	482
Nova Scotia	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Ontario	4	..	..	62	3	..	74	..	..	973	77	..	25	..	..	32	4	..	..	..	..	56	5	..	14	..	..	86	4	..	1419
Prince Edward Island	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Quebec	208	2	..	87	8	..	37	..	..	269	18	..	145	14	..	..	..	..	..	..	..	12	1	..	65	..	..	205	9	..	1080
Saskatchewan	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Yukon	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
N. W. Territories	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Totals	327	2	..	149	11	..	111	..	..	1366	95	..	170	14	..	32	4	..	..	..	..	311	6	..	79	..	..	291	13	..	2981

source. Apparently no effective action was taken and as a consequence the second outbreak occurred among citizens in 1923.

Hammond, Indiana, 1924. Because of objectionable tastes in the public water supply, probably caused by the combination of chlorine with industrial wastes, chlorination of a grossly polluted supply was discontinued temporarily. The result was an outbreak of 21 cases of typhoid fever.

Water and sewer lines in same trench

Fairmount, North Dakota, 1923. Vibration caused by railroad trains passing over tracks crossing a ditch in which both water mains

TABLE 12

Classification of causes of waterborne outbreaks in Canada, decade 1920–29 inclusive, typhoid deaths

	A1	A2	A3	B1	D1	D2	D3	F1	F3	G1	G2	TOTALS
Alberta	Report no waterborne outbreaks											
British Columbia	Report no waterborne outbreaks											
Manitoba	No report received											
New Brunswick												
Nova Scotia	No report received											
Ontario	...	...	70	1	4	9	...	...	4	...	5	93
Prince Edward Island	No report received											
Quebec	11	13	...	...	...	...	20	2	4	2	...	52
Saskatchewan	Report no waterborne outbreaks											
Yukon	No report received											
N. W. Territories	No report received											
Totals	11	13	70	1	4	9	20	2	8	2	5	145
Group totals	94			1	33			10		7		
Order	4	3	1	11	8	5	2	9	6	10	7	

and sewers were laid in the same trench caused leaking in both lines which resulted in pollution of the city water supply causing 47 cases of typhoid fever and 3 deaths.

OUTBREAKS IN PUBLIC SCHOOLS

Winston, Missouri, 1929. The seepage of sewage from toilets in the consolidated school in a shallow well used for the school water supply caused one of the most severe institutional outbreaks on

record. Out of an attendance at school of 178 pupils and teachers, there were 82 cases and 3 deaths.

Miller, Missouri, 1921. Pollution of a shallow well in a school in this town resulted in 20 cases of typhoid fever among pupils.

Reeder, North Dakota. As in the case of the Winston school, sewage from the school leaking into a dug well caused 16 cases of typhoid fever and 2 deaths. The janitor was proven a typhoid carrier.

TABLE 13

Classification of causes of waterborne outbreaks in Canada, decade 1920–29 inclusive, typhoid cases

PROVINCE	A1	A2	A3	B1	B5	C1	D1	D2	D3	F1	F3	F4	G1	G2	TOTALS
Alberta	Report no waterborne outbreaks														
British Columbia	Report no waterborne outbreaks														
Manitoba	No report received														
New Brunswick	182	300	...	...	...	...	...	...	...	...	...	...	...	...	482
Nova Scotia	No report received														
Ontario	...	28	943	20	25	42	32	113	...	...	46	21	...	56	1,326
Prince Edw. Island	No report received														
Quebec	103	262	...	...	...	...	...	...	288	27	120	...	228	...	1,028
Saskatchewan	Report no waterborne outbreaks														
Yukon	No report received														
N. W. Territories	No report received														
Totals	285	590	943	20	25	42	32	113	288	27	166	21	228	56	2,836
Group totals	1,818			45		42	433				214		284		
Order	4	2	1	14	12	9	10	7	3	11	6	13	5	8	

Van Buren, Maine, 1927. Eleven cases of typhoid fever were brought into this city as a result of its citizens drinking polluted water in the city of St. Leonard, N. B., across the river, which had a waterborne outbreak of 200 cases.

REPEAT OUTBREAKS IN SAME CITY

During the decade 1920–29 inclusive, nine repeat outbreaks in the same city were reported, five being from the same cause.

Talledega, Alabama. The public water supply in 1921–23 was obtained from a spring in fissured limestone and was subject to pollution from surface sources. Chlorination was the only treatment.

In December, 1921, the superintendent left the plant in charge of an attendant who failed to operate the chlorinator. Over twenty-five cases of typhoid fever resulted. In March, 1923, there was a heavy rate of pumpage during a fire, but the chlorine dosage was not increased. Seventeen cases of typhoid fever developed from the lack of proper control over chlorination.

TABLE 14

Classification as to cause and yearly distribution of typhoid cases for waterborne outbreaks in United States, decade 1920–29, inclusive

CLASSIFICATION	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	TOTALS
A 1	212	7	8	9	26	93	108	11	10	26	510
2	40	111	60	.....	58	16	.....	30	25	.....	340
3	.....	10	69	.....	.....	.....	.....	.....	.....	.....	79
4	.....	61	40	140	22	105	58	3	.....	25	454
5	60	.....	.....	19	.....	18	.....	15	.....	11	123
B 1	33	119	67	78	13	17	86	45	37	165	660
2	.....	.....	.....	15	.....	.....	.....	.....	.....	5	20
3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	.....	36	.....	.....	.....	.....	.....	.....	37	.....	73
5	.....	21	31	.....	81	18	.....	23	37	78	289
6	.....	31	10	.....	.....	.....	92	.....	.....	.....	133
7	.....	.....	.....	.....	.....	.....	.....	.....	.....	50	50
8	.....	.....	12	.....	369	.....	.....	.....	.....	.....	381
C 1	.....	.....	42	.....	.....	.....	.....	26	.....	.....	68
2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
D 1	258	.....	58	33	12	17	8	10	.....	.....	396
2	8	29	.....	267	144	.....	284	179	28	46	985
3	262	73	22	40	111	21	.....	.....	49	16	594
F 1	.....	.....	.....	.....	.....	.....	.....	13	.....	.....	13
2	.....	.....	.....	47	.....	.....	.....	.....	.....	.....	47
3	241	.....	114	279	21	1,054	102	111	.....	73	1,995
G 1	.....	12	.....	.....	.....	.....	37	.....	20	.....	69
2	884	.....	.....	230	182	.....	54	.....	259	205	1,814
H 1	5	.....	.....	.....	.....	.....	.....	.....	.....	85	90
2	.....	10	.....	.....	.....	.....	.....	.....	.....	60	70
3	.....	.....	17	.....	.....	.....	20	20	.....	3	60
4	.....	30	13	11	.....	.....	.....	.....	.....	.....	54
Totals.....	1,003	550	563	1,168	1,039	1,359	849	486	502	848	9,367

Fort Wayne, Indiana. In November, 1923 a cross connection between the city water supply and a private supply of the Pennsyl-

vania Railroad caused pollution of the city water resulting in 140 cases of typhoid fever and 20 deaths. A similar cross connection with a private supply of the Wabash railroad caused 53 cases of typhoid fever, 500 cases of dysentery and 3 deaths in March, 1929.

Herington, Kansas. (See Unusual Outbreaks.)

Albany, New York. Water in a leaking gravity conduit used for delivering water from the filtration plant to the city and laid under the bed of an abandoned canal, became polluted in April, 1924, with canal water and a typhoid outbreak of 114 cases and 14 deaths followed.

TABLE 15

Classification as to cause and yearly distribution of typhoid cases for waterborne outbreaks in Canada, decade 1920–29 inclusive

CLASSIFICATION	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	TOTALS
A 1	115	.....	.....	127	.....	.....	.....	43	.....	.....	285
2	.....	87	37	124	37	.....	.....	212	65	28	590
3	4	.....	.....	935	.....	.....	.....	.....	.....	4	943
B 1	.....	6	.....	.....	.....	.....	.....	.....	14	.....	20
5	.....	.....	.....	.....	25	.....	.....	.....	.....	.....	25
C 1	.....	.....	.....	.....	.....	.....	.....	.....	.....	42	42
D 1	.....	.....	.....	.....	.....	32	.....	.....	.....	.....	32
2	.....	56	19	38	.....	.....	.....	.....	.....	.....	113
3	.....	.....	.....	.....	88	.....	.....	.....	.....	200	288
F 1	.....	.....	.....	27	.....	.....	.....	.....	.....	.....	27
3	.....	.....	34	115	.....	.....	.....	.....	.....	17	166
4	.....	.....	21	.....	.....	.....	.....	.....	.....	.....	21
G 1	208	.....	.....	.....	20	.....	.....	.....	.....	.....	228
2	.....	.....	.....	.....	.....	.....	.....	56	.....	.....	56
Totals.....	327	149	111	1,366	170	32	.....	311	79	291	2,836

In October, 1928, due to pollution of the city water supply by a cross connection at an industrial plant, 30 cases of typhoid fever, 80 cases of dysentery and one death resulted.

Oswego, New York. Ten cases of typhoid fever and two deaths were the result of pollution of the city water supply in August, 1927 by a cross connection at an industrial plant.

In December, 1927, an outbreak of 500 cases of dysentery followed failure to apply sufficient chlorine to disinfect water obtained from a lake during a period of high turbidity.

Grand Forks, North Dakota. In January, 1928, twenty percent

of the population (1500) of this city suffered from dysentery caused by pollution of the public water supply by river water entering a leak in a suction line crossing the river. Again in February, 1929, there was a generalized outbreak of dysentery throughout the city from the same cause.

TABLE 16

Classification as to causes and yearly distribution of typhoid deaths for waterborne outbreaks in the United States, decade 1920–29 inclusive

CLASSIFICATION	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	TOTALS
A 1	17	.....	.....	.....	.....	2	.....	.....	.....	5	24
2	11	3	6	.....	11	.....	.....	6	3	.....	40
3	.....	.....	4	.....	.....	.....	.....	.....	.....	.....	4
4	.....	.....	5	7	1	5	.....	.....	.....	1	19
5	3	.....	.....	3	.....	.....	.....	1	.....	.....	7
B 1	.....	4	10	7	.....	.....	.....	6	5	8	40
2	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	3
3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
5	.....	1	3	.....	2	3	.....	.....	4	8	21
6	.....	4	4	.....	.....	.....	4	.....	.....	.....	12
7	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	3
8	.....	.....	.....	.....	28	.....	.....	.....	.....	.....	28
C 1	.....	.....	3	.....	.....	.....	.....	.....	.....	.....	3
2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
D 1	28	12	1	4	2	1	1	.....	.....	.....	49
2	.....	.....	.....	30	12	.....	18	29	.....	1	90
3	13	.....	2	2	.....	.....	.....	.....	3	1	21
F 1	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	1
2	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	3
3	34	.....	18	44	.....	5	8	8	.....	9	126
G 1	.....	.....	.....	.....	.....	.....	4	.....	2	.....	6
2	27	.....	.....	15	14	.....	5	.....	16	17	94
H 1	.....	.....	.....	.....	.....	.....	.....	.....	.....	6	6
2	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	3
3	.....	.....	4	.....	.....	.....	2	.....	.....	1	7
4	.....	3	.....	1	.....	.....	.....	.....	.....	.....	4
Totals.....	133	30	60	119	70	16	42	51	33	60	614

Sturgeon Bay, Wisconsin. Leakage from a public sewer through creviced limestone into a private well at a hospital caused 21 cases of typhoid fever and one death in November, 1921. Due to the same condition, which had not been corrected in the meantime, there was a

second outbreak at this hospital in June, 1922, with 31 cases of typhoid and 3 deaths. A similar condition at another well in town caused 20 cases of typhoid fever and 2 deaths in May, 1924.

Surface pollution by privies and the resulting pollution of shallow wells and cesspools in limestone, caused 70 itinerant cases of typhoid fever and 7 deaths in August, 1929.

Wausau, Wisconsin. A cross connection at an industrial plant caused 7 cases of typhoid, 20 of dysentery and 3 deaths in July, 1923. The failure completely to eliminate this cross connection resulted in a second outbreak in June, 1924, with 4 typhoid and 60 dysentery cases.

TABLE 17

Classification as to causes and yearly distribution of typhoid deaths for waterborne outbreaks in Canada, decade 1920–29 inclusive

CLASSIFICATION	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	TOTALS
A 1	.....	.....	.....	11	.....	.....	.....	.....	.....	.....	11
2	.....	8	.....	1	3	.....	.....	1	.....	.....	13
3	.....	.....	.....	70	.....	.....	.....	.....	.....	.....	70
B 1	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	1
D 1	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	4
2	.....	2	.....	7	.....	.....	.....	.....	.....	.....	9
3	.....	.....	.....	.....	11	.....	.....	.....	.....	9	20
F 1	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	2
3	.....	.....	.....	4	.....	.....	.....	.....	.....	4	8
G 1	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
2	.....	.....	.....	.....	.....	.....	.....	5	.....	.....	5
Totals.....	2	11	.....	95	14	4	.....	6	.....	13	145

Fond du Lac, Wisconsin. In March, 1922, twelve cases of typhoid fever were contracted as a result of pollution of the public water supply by sewage through a connection of the exhaust from an air lift booster tank to the sewer. A sharp outbreak of 50 typhoid cases and 3 deaths occurred in this city in October, 1929, through pollution of the water in the public wells by river water entering an abandoned well in a relocated river channel.

DAMAGE SUITS RESULTING FROM WATERBORNE OUTBREAKS

During the decade 1920–29 considerable history has been made in the courts in the United States and Canada in fixing the liability of

cities, private water companies and industries for illness or death resulting from pollution of public water supplies. The courts have awarded substantial damages against cities and companies subjecting the public to health hazards through carelessness or negligence. Notations on such decisions are given briefly below.

TABLE 18

Classification as to causes and yearly distribution of dysentery cases for waterborne outbreaks in the United States, decade 1920–29 inclusive

CLASSIFICATION	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	TOTALS
A 1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2	.....	26	100	.....	.....	.....	.....	.....	59	.....	185
3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	5
5	.....	.....	.....	.....	.....	.....	.....	.....	400	.....	400
B 1	.....	.....	.....	.....	.....	.....	.....	.....	1,000	1,005	2,005
2	.....	.....	.....	.....	.....	114	.....	78	.....	.....	192
3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
5	.....	.....	.....	.....	.....	.....	.....	.....	89	1,000	1,089
6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	.....	.....	.....	.....	10,200	.....	.....	450	.....	.....	10,650
C 1	.....	.....	500	.....	.....	.....	34	.....	735	.....	1,269
2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
D 1	.....	.....	200	.....	111	2,000	45,000	.....	.....	.....	47,311
2	.....	373	.....	300	.....	.....	109	600	.....	.....	1,382
3	32	.....	.....	.....	.....	.....	.....	.....	.....	.....	32
F 1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	1,075	.....	.....	20	60	.....	.....	80	.....	5,300	6,535
G 1	.....	2,000	.....	.....	.....	.....	.....	.....	300	.....	2,300
2	7,000	.....	.....	.....	240	2,000	.....	.....	300	.....	9,540
H 1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	.....	.....	.....	.....	.....	600	.....	.....	.....	.....	600
4	.....	500	.....	.....	.....	.....	.....	.....	.....	.....	500
Totals...	8,112	2,899	800	320	10,611	4,714	45,143	1,208	2,883	7,305	83,995

UNITED STATES

Olean, New York. An act authorizing the city of Olean to issue bonds to the amount of $350,000 was passed by the state legislature and signed by the Governor in February, 1930, to pay the cost of

TABLE 19

Annual distribution of waterborne outbreaks in the United States, decade 1920–1929 inclusive; typhoid cases, deaths, and dysentery cases

	1920			1921			1922			1923			1924			1925			1926			1927			1928			1929			TOTAL
	Typhoid	Deaths	Dysentery	Typhoid	Deaths	Dysentery	Typhoid	Deaths	Dysentery	Typhoid	Deaths	Dysentery	Typhoid	Deaths	Dysentery	Typhoid	Deaths	Dysentery	Typhoid	Deaths	Dysentery	Typhoid	Deaths	Dysentery	Typhoid	Deaths	Dysentery	Typhoid	Deaths	Dysentery	
Alabama	35			25						17			17																		94
Arizona	20																											60	16	350	446
Arkansas	Report no waterborne outbreaks																														
California	144	2		73	3								394	28	10,400													8	1		11,053
Colorado	Report no waterborne outbreaks																														
Connecticut	Report no waterborne outbreaks																														
Delaware	Report no waterborne outbreaks																														
District of Columbia	Report no waterborne outbreaks																														
Florida	Report no waterborne outbreaks																														
Georgia													35		40																75
Idaho	40	11																				7	3		15						76
Illinois	200	24	1,075							150	15					30	5	4,000	34	3		23		78			1,100			1,000	7,737
Indiana	18	2								152	26		33	2		1,000		600						450				53	3	5,000	7,339
Iowa	33			8															27			26					35	25	1	5	160
Kansas										79	7																				86
Kentucky							76	11	100	100	15	300	55	11		40	5								15	2		15	1		746
Louisiana	Report no waterborne outbreaks																														
Maine							51	10														11									72
Maryland			37	32			16			35	1		20			27	1		44		34	49	3		51	3					353
Massachusetts	Report no waterborne outbreaks																														
Michigan	118	11		19			69	4								14			28	3	45,000										45,266
Minnesota				10	3		13			2												13	1				89			300	431
Mississippi							42	3	500	40	4																				589
Missouri				20									8	1		21		114									1,000	82	3	1,000	2,249
Montana																												205	17		222
Nebraska										15	3																				18

New Hampshire	Report no waterborne outbreaks																																				
New Jersey				7			124	22		44	7		10			33			11			3						2			263						
New Mexico	152	15																				54	9		14	1					245						
New York	285	21		85	4					19	3		114	14		76	3		382	23	109	98	8	580	245	15					2,084						
Nevada	Report no waterborne outbreaks																																				
North Carolina																			37	4											41						
North Dakota										47	3														23	2	300				375						
Ohio	884	37	7,000	52	15	2,373																7			37	4					10,409						
Oklahoma																			36	3											39						
Oregon																						25	3				59				87						
Pennsylvania				125		526	24		200	89			104			45			181			14			38						1,346						
Rhode Island																			15	1											16						
South Carolina	No report received																																				
South Dakota							25	4								35	2														66						
Tennessee																18						15	1		14	2	300				350						
Texas																													92	5		97						
Utah										230	15		144	12															19	5		425						
Vermont													17																			17						
Virginia	15												61			17			54	5		141	23	100	19	1					172						
Washington										142	17																				159						
West Virginia	40	2		32			80	3					3		111										31	3		147	8		724						
Wisconsin	19	8		62	5		43	3		7	3	20	24	2	60	3												140	16		415						
Wyoming	Classification of causes of outbreak not given																																				
Total	2,003	133	8,112	550	30	2,899	563	60	800	1,168	119	320	1,039	70	10,611	1,359	16	4,714	849	42	45,143	486	51	1,208	502	33	2,883	848	76	7,655	94,342						

TABLE 20

Classification by causes of waterborne outbreaks in the United States, decade 1920–1929 inclusive, typhoid cases

	A					B								C		D			F				G		H					TOTAL
	1	2	3	4	5	1	2	3	4	5	6	7	8	1	2	1	2	3	1	2	3	4	1	2	1	2	3	4	1	2	3	4	
Alabama																35	17	25						17									94
Arizona	20																									60							80
Arkansas	Report no waterborne outbreaks																																
California	14	31				6			36				369					144						16			3						619
Colorado	Report no waterborne outbreaks																																
Connecticut	Report no waterborne outbreaks																																
Delaware	Report no waterborne outbreaks																																
District of Columbia	Report no waterborne outbreaks																																
Florida	Report no waterborne outbreaks																																
Georgia																								35									.....
Idaho		47																15															62
Illinois										41	34						150				212												437
Indiana																30		33			1193												1256
Iowa					11	69	5			8				26																			119
Kansas				79																													79
Kentucky		91		80		15											100	15															301
Louisiana	Report no waterborne outbreaks																																
Maine	11					51																											62
Maryland	16			18		142			37							17		24									20						274
Massachusetts	Report no waterborne outbreaks																																
Michigan			69													8	19	118			14						20						248
Minnesota																			13		2					10		13					38
Mississippi						40								42																			82
Missouri				8		102												21															131
Montana																								205									205
Nebraska							15																										15
New Hampshire	Report no waterborne outbreaks																																
New Jersey	48			7							10										169												234
New Mexico	152																54							14									220

| | | |

TABLE 21

Classification by causes of waterborne outbreaks in the United States decade 1920–1929 inclusive, typhoid fever deaths

STATE	A					B								C		D			F				G		H				TOTALS
	1	2	3	4	5	1	2	3	4	5	6	7	8	1	2	1	2	3	1	2	3	4	1	2	1	2	3	4	
Alabama																													
Arizona																										16			16
Arkansas	Report no waterborne outbreaks																												
California		3											28					2									1		34
Colorado	Report no waterborne outbreaks																												
Connecticut	Report no waterborne outbreaks																												
Delaware	Report no waterborne outbreaks																												
Florida	Report no waterborne outbreaks																												
Georgia																													
Idaho		14																											14
Illinois										3	3						15				26								47
Indiana																4		2			27								33
Iowa										1																			1
Kansas				7																									7
Kentucky		17		10		1											15	2											45
Louisiana	Report no waterborne outbreaks																												
Maine						10																							10
Maryland						7										1													8
Massachusetts	Report no waterborne outbreaks																												
Michigan			4													1		11									2		18
Minnesota																			1							3			4
Mississippi						4								3															7
Missouri				1		3																							4
Montana																								17					17
Nebraska							3																						3
New Hampshire																													
New Jersey											4										25								29
New Mexico	15																9							1					25
New York					6	4					1					16	18				17			29					91
Nevada	Report no waterborne outbreaks																												

Nevada	Report no waterborne outbreaks									1						16	18				17			29					91

North Carolina																							4					4
North Dakota						2														3								5
Ohio										4						22							27				3	65
Oklahoma																					3							3
Oregon						3																						3
Pennsylvania																												
Rhode Island																					1							1
South Carolina	No Report Received																											
South Dakota	2																								4			6
Tennessee					1																		2					3
Texas				1		4																						5
Utah	5																12							15				32
Vermont																												
Virginia																		1						5				6
Washington						2										4					10						1	17
West Virginia	2	6														1	21	3							6			39
Wisconsin										13	4	3									17							37
Wyoming	Classification of causes of outbreaks not given*																											
District of Columbia	Report no waterborne outbreaks																											
Total	24	40	4	19	7	40	3	0	0	21	12	3	28	3	0	49	90	21	1	3	126	0	6	94	6	19	7	4	630
Group total	94					107								3		160			130				100		36			630
Order	8	6	18	11	16	5	23	—	—	9	13	20	7	21	—	4	3	10	24	22	1	—	17	2	15	12	14	19	

* 139 deaths from typhoid fever in Wyoming during decade. Practically all reported waterborne, but no major outbreaks.

TABLE 22

State distribution of number of waterborne outbreaks in the United States, decade 1920–1929

STATE	A					B								C		D			F				G		H				TOTAL
	1	2	3	4	5	1	2	3	4	5	6	7	8	1	2	1	2	3	1	2	3	4	1	2	1	2	3	4	
Alabama																1	1	1						1						4
Arizona	1																										1			2
Arkansas	Report no waterborne outbreaks																													
California	2	2				1			1				1					1						1			1			10
Colorado	Report no waterborne outbreaks																													
Connecticut	Report no waterborne outbreaks																													
Delaware	Report no waterborne outbreaks																													
Florida	Report no waterborne outbreaks																													
Georgia																								1						1
Idaho		2																1												3
Illinois					1		1			2		2		1		1	1				3			1						13
Indiana													2			2		2			3						1			10
Iowa					1	5	1			1				2																10
Kansas				1																										1
Kentucky		3		2		1											1	1												8
Louisiana	Report no waterborne outbreaks																													
Maine	1					1																								2
Maryland	2			3		10			1					1		1		2									1			21
Massachusetts	Report no waterborne outbreaks																													
Michigan			1										1			1	1	1			1						1			7
Minnesota										1									1		2					1		1		6
Mississippi						1								1																2
Missouri				1		3	1											1												6
Montana																								1						1
Nebraska							1																							1
New Hampshire	Report no waterborne outbreaks																													
New Jersey	4		2								1										3									10
New Mexico	1																1							1						3
New York				1	2	1					1					4	2				6			2	1					20

Nevada	Report no waterborne outbreaks																												
North Carolina																							1						1
North Dakota						2														1				2					5
Ohio		1								1						2	1						1	1				1	8
Oklahoma																					1								1
Oregon		1				1															1								3
Pennsylvania	5	4		7		1										1	1	3			1							1	24
Rhode Island																					1								1
South Carolina	No report received																												
South Dakota	3	1																								1			5
Tennessee					2													1					1						4
Texas				1		1																							2
Utah	1																1							1					3
Vermont																					1								1
Virginia					1	1				1							1	1						1					6
Washington						1										1					1							2	5
West Virginia	1	7														3	4	2					1		1				19
Wisconsin			1							4	1	1	1								5								13
Wyoming	Classification of causes of outbreaks not given																												
District of Columbia	Report no waterborne outbreaks																												
Total	21	21	4	16	7	30	4	0	2	10	3	3	5	5	0	17	15	17	1	1	29	0	4	3	2	2	5	5	242
Group total			69						57					5			49			3	1		1	7		1	4		

TABLE 23

Classification of waterborne outbreaks in the United States, decade 1920–1929 inclusive, dysentery cases

	A					B								C		D			F			G			H				TOTAL
	1	2	3	4	5	1	2	3	4	5	6	7	8	1	2	1	2	3	1	2	3	1	2	3	1	2	3	4	
Alabama																													
Arizona																										350			350
Arkansas	Report no waterborne outbreaks																												
California													10,200										200						10,400
Colorado	Report no waterborne outbreaks																												
Connecticut	Report no waterborne outbreaks																												
Delaware	Report no waterborne outbreaks																												
District of Columbia	Report no waterborne outbreaks																												
Florida	Report no waterborne outbreaks																												
Georgia																							40						40
Idaho																													
Illinois					400		78			1,000				700		2,000				1,075			2,000						7,353
Indiana													450							5,000							600		6,050
Iowa						5								35															40
Kansas																													
Kentucky		100															300												400
Louisiana	Report no waterborne outbreaks																												
Maine																													
Maryland				5										34				32											71
Massachusetts	Report no waterborne outbreaks																												
Michigan																45,000													45,000
Minnesota										89										300									389
Mississippi														500															500
Missouri						2,000	114																						2,114
Montana																													
Nebraska																													
New Hampshire																													
New Jersey																													
New Mexico																													

| | | |

the waterborne typhoid fever epidemic which occurred in the fall of 1929. These bonds will redeem temporary loan certificates issued by the city to pay expenses and claims resulting from this epidemic. The bonds are to be redeemed in twenty years by money raised through taxes.

Albany, New York. The Appellate Division of the Supreme Court of New York unanimously affirmed the action of a Supreme Court jury which in November, 1926, awarded $2,000 to a minor and $1,000 to his father as damages for permanent injury to the son's health as a result of typhoid fever contracted from drinking polluted water from the city supply.

In March, 1930, the city lost its third suit resulting from this waterborne outbreak when a mother was awarded damages of $3,600 for the death of her daughter from typhoid fever contracted from drinking city water.

A score of other suits against the city, which have been held in abeyance pending the outcome of these suits, are expected to be brought because of the success of the plaintiffs.

Ogden, Utah. There are a number of suits pending in the state courts filed by relatives of persons who died as a result of this typhoid fever outbreak.

Everett, Washington. Three persons were awarded $6,000 each as damages against the city resulting from sickness caused during the typhoid outbreak of July–October, 1923. The court ruled that the city as a dealer in water could not shift its responsibility to produce a safe product.

Fort Wayne, Indiana. Damages of $115,000 and court costs of $1,098 were, in August, 1930, paid on a fifty-fifty basis by the city of Fort Wayne and the Pennsylvania Railroad on order of the Indiana appellate court to persons who brought suit for illness caused by typhoid fever at the time of the cross connection epidemic in 1923. The clerk of Allen county who turned over this money said this was the largest award ever made in this office.

It is understood that other suits are before the courts of Indiana from the second cross connection outbreak of 1929.

City "A" Texas. The private water company in this city settled for $15,000 damages against it resulting from a waterborne typhoid outbreak in September, 1929, which caused 25 cases and one death.

CANADA

Owen Sound, Ontario. In a test case brought by a citizen who contracted typhoid during the 1925 outbreak, Justice Logie of the Supreme Court of Ontario awarded $2,000 damages and severely rebuked the city officials for negligence in not taking proper precautions to safeguard the public water supply. If this judgment is upheld by the appellate division, it is expected that many other awards will be made in suits pending. (Susan McQueen vs Municipal Corporation of the City of Owen Sound and the Public Utilities Common for the city of Owen Sound and the Board of Health of the City of Owen Sound.)

Jordan, Ontario. In April, 1921, damages of $3,200 and costs were awarded to parents and two minor children for loss of wages, medical services and other expenses incident to sickness by typhoid fever contracted from drinking contaminated water from a well owned by the Dominion Canners Ltd., while the plaintiffs were employees and tenants of this company in 1920. Negligence of the defendant in not making proper sanitary arrangements in and about the factory and grounds of tenants was charged and sustained. (Dominion Canners vs Horace Costanza et al.)

Kingsville, Ontario. In a decision of much importance, Judge Raney of the Ontario Supreme Court awarded damages of $2,000 and costs to a woman for illness by typhoid fever contracted during the waterborne outbreak of 1927. Six other suits involving alleged damages totaling $86,000 were dismissed as they had not been filed within the legal period of six months after the damage occurred. (Campbell vs Kingsville, Ontario.)

PROBLEMS OF ST. PAUL WATER SUPPLY[1]

By Leonard N. Thompson[2]

Water supply problems in the City of Saint Paul have not been particularly difficult nor do they differ, I suppose, very much from the problems of the usual city of its size. We have been particularly fortunate from the beginning in having always near at hand a large number of lakes which have to date afforded excellent opportunities for the water works men and have given to the city a water supply system for a minimum expenditure. Of course, there have been the usual series of major extensions from time to time, and to some of you a brief description of the works may, I hope, be of interest.

Saint Paul has a population of 272,000 people, not including the population of several suburbs which are supplied with water, West Saint Paul or South Saint Paul. Lying on both sides of the Mississippi River, its topography may be described as consisting of three main levels: the bottom lands just above the river; the middle which includes the principal business and wholesale districts; and the plateau or high level which includes most of the residential section. The principal business section is on a slope rising to about 100 feet above the river. The residential sections are mostly on high ground from 100 to 200 feet above the river, with an extreme rise of about 340 feet. The country to the east as far as the St. Croix nowhere rises much higher than Saint Paul, and the lakes are generally lower.

To the north of the city lies a chain of lakes which are generally about the same elevation as the high level. These lakes, some 14 in number, are all within a 20 mile radius of the city, and afforded for years an ample water supply.

In 1910, which was a very dry year, with rainfall of only 10.21 inches, the city experienced a water shortage, and upon the advice of Dabney H. Maurey, employed as a consulting engineer, drilled 34 wells, of average depth of about 600 feet and which yielded about 16 million gallons a day. In 1911 the rainfall was approximately 41

[1] Presented before the Wisconsin Section meeting, August 21, 1930.

[2] General Superintendent and Engineer, Water Department, St. Paul, Minn.

inches and the lakes replenished, so the wells have been used but a few times. By 1920 the city consumption had increased to the point where additional supply was necessary. After a study of several sources, it was decided to tap the Mississippi River at a point some 6 or 7 miles north of the city of Minneapolis, and pump the water across country approximately 8 miles, into the chain of lakes. The water thus taken from the river is used to replenish the lake system.

THE FRIDLEY CONDUIT

The entire project, including the conduit, the pumping station, pumping equipment, canal between Charles and Pleasant Lakes, and the stand-pipe, was termed the Fridley Conduit.

The capacity of the conduit in the preliminary plans was fixed at 40 million gallons daily. This seemed ample when it was considered that the average daily consumption in the city at that time did not exceed 25 m.g.d., and that the lake system alone would normally product 15 m.g.d., with the well system in reserve. Later the capacity of the conduit was increased to 60 m.g.d., as a medium between first cost and future needs.

Wood stave, cast iron, steel and reinforced concrete were considered as the material of which the conduit could be constructed. A continuous wood stave pipe would have entailed the lowest first cost by a wide margin. Soil conditions, however, eliminated it. Much of the right-of-way is of peat formation and slightly acid, which would have been detrimental to the steel hoops. Practically all the balance of the ground is almost pure silica sand, which was not best for untreated wood. Although creosoted treated wood has been used successfully for waterworks, we were a bit afraid of tastes in the water. Further, soil conditions were such that it would have been difficult to have obtained good workmanship in the invert.

Cast iron pipe was prohibitive due to the cost.

Steel pipe coated with a special coating of a semi-rubber base was used for the first 8,150 feet where the head was comparatively high. First cost, anticipated useful duration, maintenance, leakage, soil conditions, dependability under railroad tracks, were taken into consideration in making the decision.

The balance of the conduit, a distance of 33,107 feet, is of reinforced concrete. Reinforced concrete was less in first cost than steel and about double the cost of wood stave pipe. However, when soil conditions, internal pressure, maintenance and length of anticipated

service were considered, it was evident that it was the best proposition for the greater portion of the conduit.

Pre-cast concrete pipe against pouring it in place in the trench was considered. The Lock Joint Pipe Company of New Jersey, and the Independent Pipe Company of Indianapolis submitted figures for pre-cast concrete pipe. However, soil conditions, with unsatisfactory and difficult delivery of the pipe along the line and the placing of it were such as to make its cost prohibitive.

Construction of conduit

Therefore, all things considered, it was decided to use steel forms and pour the conduit directly in place. It can hardly be called monolithic for the joints were placed every 20 feet, and the invert was poured separately from the crown portion. The conduit has an internal diameter of 60 inches, with walls 6 and 8 inches thick. The 6-inch walls were used where soil conditions were good and the internal pressure low; otherwise, where the pressure exceeded 35 feet or where the foundation was such that settlement would be expected, 8-inch walls were used. Also the 8-inch walls were used where the conduit was supported on piling.

Construction difficulties were very much increased due to the fact that water, quicksand, or peat bog was prevalent for approximately 6½ miles out of the eight. Innumerable springs were encountered, which were not apparent from test pits. In places yellow sand would roil upward through as much as 2 feet of blue sand.

Through the peat bogs, a distance of 6,700 feet, piling was driven. The bogs at places were extremely deep and soft, 60-foot piling being required in some instances. The piling, too, at times sank as much as 37 feet under the weight of the hammer before a blow was struck.

Construction joints

A great deal of thought was given to a suitable construction joint. It consists of a plain copper ring, 9 inches wide, placed in the center of the concrete wall. On the inside face of the conduit ring there was molded by means of an aluminum form a depression 1 inch deep and 6 inches wide with a center V-shaped groove. The V-groove was then filled with a soft asphalt and the 1-inch depression was filled with a cement grout reinforced with hardware cloth. The idea was to permit movement and still have it water-tight. Over the grouting was placed asphalt and a layer of saturated cotton fabric.

Our decision to make the joints every 20 feet was based on experience and practice in other places. A monolithic construction was considered as was done, I believe, on the Los Angeles aqueduct, and also placing the joints at 40 feet.

The longitudinal joint between the invert and the crown section has given no trouble. In fact, we have yet to discover leaks from this source. A very simple joint, consisting of a groove in the invert, was used. The steel forms for the crown section permitted grout to flow down over the joint, which aided in sealing it.

By means of a Price current meter and also with floats we have endeavored to measure the leakage. The pumping station is equipped with a Venturi meter, and as far as can be ascertained by the methods of measurement used, the leakage is negligible.

We did not bulkhead the outlet of the conduit and measure the leakage by displacement from a tank, believing conditions did not warrant the cost and danger of damaging the conduit.

Air valves

Air valves were placed on the high points. Some are automatic and some manual. On the steel pipe to prevent collapse from sudden emptying a 6-inch automatic air valve is in service as well as a 6-inch check valve.

A suitable type of air valve has been hard to get due to the fact that at many places where vents were needed, pressures are so low that the automatic valves do not close tight, causing splitting of the valves, and, in winter, freezing. A sudden cutting off of power the first winter of operation when trouble was experienced with the freezing air valves was the later cause of considerable trouble with some of the expansion joints.

Surge tank

A steel surge tank, 12 feet in diameter and 98 feet high, was placed in the conduit line on the crest of the river embankment, about 150 feet from the pumping station. This tank is open at the top, its function being to reduce vibration in the pipe line, steady the flow of water, and to prevent damage from water hammer if the electric power should fail suddenly.

Intake and pumping station

The pumping station, 50 by 60 feet in plan, and the intake, 27 feet by 41 feet 6 inches in plan, are housed under the same roof.

The building is supported on piling and was made heavy enough to resist buoyancy from the water.

Considerable difficulty was encountered in the construction due to the fact that the station is at the foot of a 60-foot embankment of very unstable material. A coffer-dam was constructed and the excavation carried down 10 feet below low-water level in the river, or approximately 25 feet below ground level on the embankment side. The pressure from the embankment was extremely hard to resist, due to lack of a suitable support on the river side.

The intake extends out into the river with a floor elevation about 5 feet lower than low-water level in the river.

There are three intake openings provided with sluice gates and trash racks.

Inside the building are two traveling Rex water screens having a screen mesh of $\frac{1}{8}$-inch. We have experienced very little trouble from ice or needle ice; however, steam jets were provided if needed to fight this trouble. More trouble is found from weeds early in the fall.

Two pumps are now in operation. They are of the electrical motor driven centrifugal type of 10 and 20 m.g.d. capacity. Provision was made for the installation of additional pumps to increase the capacity of the station to 60 m.g.d. when necessity demands. These additional pumps will be installed this winter.

Difficulties with expansion joints

Since the construction of this conduit we have had some trouble with the type of expansion joint which was used, this trouble occurring after the water in the river and the ground begins to change temperature in the fall As originally installed the circular expansion and contraction joints at 20-foot intervals and the longitudinal construction joints were covered with hot asphalt and special impregnated fabric. To insure the concrete being perfectly dry, large blow torches were used against the concrete just previous to applying the asphalt. After the first winter we found that it was practically impossible to keep any type of hot applied asphalt to adhere to the concrete, and all asphalt-impregnated cloth soon peeled off and washed away. For several seasons we experimented with various brands of plastic asphaltic products as roofing cement, etc., but had very little success in securing a seal that would be successful over two winters. Lead wool and cement were used, but were found to

be a one year remedy. Three years ago we hit upon the idea of using a wide circular steel plate, 8 inches wide, set over the leaking joints on the inside of the conduit. An annular space of ¼-inch between the plate and the concrete was tamped full of crumbly cement. Later we followed the practice of tamping only the outer 3-inches on each end of the plate with cement and forcing roofing cement into the balance of the space by use of a grease gun after the cement had set. These joints have proved 100 percent efficient after several winters. Their use would not be recommended as original installation, mainly because of their cost, but have proven an exceptionally good method of sealing a leaky joint in concrete conduits which are subject to expansion and contraction. Our experiences on this conduit showed that about every fourth or fifth joint would show movement in the fall, so in 1925 when a somewhat similar conduit of 90-inch internal diameter and 4½ miles in length was constructed, the expansion joints were placed 40 feet apart, and the copper ring instead of being plain was beaded and at the joint a deep recess ⅜-inch wide by 2 inches deep was made in the concrete on the inside of the conduit. This recess was filled tight with roofing cement and has proved a very satisfactory joint.

VADNAIS LAKE STEEL PIPE CONDUIT

This particular conduit extends in Vadnais Lake approximately 400 feet in the form of a steel pipe. At the outer end was placed a ¼-inch mesh screen 6 feet long and circular, of the same diameter as the intake pipe. From the experiences we have had, I should say this was far from a satisfactory type of screen to use at the end of an intake. During the summer months a crew of men is employed a great deal of the time in cutting weeds in the lakes. Many of these weeds float and are carried by winds towards the intake screen. Because of the circular shape of the screen considerable difficulty is experienced in cleaning off these weeds.

SOURCES OF SUPPLY

The chain of water supply lakes used by the department consists of 14 in number having a normal water surface of 124 square miles and a water shed of 5700 acres. To patrol these lakes requires constantly the services of a crew of some 12 or 15 men, and the problem of keeping them clear of weeds is a major part of their duties. In water up to a depth of about 4 feet this is accomplished by motor

driven scows and weed scythes. In deeper water we find the best and most lasting results are obtained by using two scows and operating between the two crews a narrow double edge steel saw which is allowed to drag on the lake bottom as it is pulled to and fro between the boats.

On a large part of the watershed the department has since 1914 been planting each year several thousand evergreens. Approximately 500,000 trees are standing today, earlier plantings being 10 to 15 feet in height. Varieties are Scotch and Norway, Riga, White and Jack Pines, Blue and Black Hills Spruce, Cedars and Balsams Firs. Unfortunately, the trees have not only had to withstand the natural difficulties of drought, severe winters, disease and fires, but have also suffered at the hands of a vandal public, who have a fondness for them for Xmas trees and ornamental purposes in their lawns. The plantings have been depleted more from fire, trespassing and theft than failure and disease.

Tastes and Odors

A period of approximately 6 weeks is normally used in travel of the raw water from the Mississippi River through the chain of lakes and to the filter plant. At turnover periods of the lake water, spring and fall, tastes and odors were for many years a real problem to the department and occasioned an avalanche of complaints each fall. Upon completion of the Filtration Plant the existing provision for open air aeration at the storage reservoir was frowned upon by the Minnesota State Board of Health. So in 1926 experiments were begun with introduction of air into the water, it being established that when the dissolved oxygen content was low, odors were most likely to increase in the water. An electric driven air compressor was installed in the mixing chamber and the air piped to pipes lying upon the floor of the mixing chamber at the approximate point of entry of the water into the chamber. These pipes are two in number, approximately 12 feet apart and 12 feet long, or the width of the mixing chamber. Staggered and at an angle of 45° with each other are drilled two rows of $\frac{3}{16}$-inch holes. Application of the air is at the rate of 6000 cubic feet per million gallons of water, diffused through the water under a pressure of approximately 5 pounds. Results have been particularly gratifying and complaints from taste and odor have been practically eliminated. The air is forced through the water, which is usually about 20 feet deep, at such a rate that actual

ventilation takes place much the same as air is changed in a room. The odor of the gases carried out is often distinctly noticeable.

SERVICE PIPES

Of the many elements forming the various parts of a water works system service pipes seem to be the least standardized. The problem of selecting suitable material for service connections is a real one when it is considered that in Minnesota, for the most part, connections are laid quite deep—that is, practically 8 feet—and that they are covered by a heavy expensive pavement which can be more or less damaged by a defect in the service, and we all understand how costly waste of water is as well as making repairs. Aside from the practical and physical feature of the service connection, the corrosiveness of the material and its effect upon health must also be taken into consideration. Various metals have been used and all have been more or less satisfactory.

I think that our experience in St. Paul has been as varied as in almost any other city. For many years extra strong lead with brass fittings was used almost exclusively. In time the 2-inch size began to give trouble due to the fact that the lead did not have tensile strength enough to resist bursting pressure. Galvanized iron was then substituted and was used for many years almost exclusively for the 2-inch, although the 1½-inch and smaller still continued in lead. The galvanized iron pipe had a life considerably longer than black iron; however, it corroded rather badly and its average life was not longer than fifteen years.

In order to better this service, when cast iron pipe was to be had in the 2-inch size we adopted its use, and while it gave satisfaction, we found that it was quite brittle, and exceptional care was needed in handling it to keep it from breaking. We also found that it was not uniform in cross section, that is, while it contained sufficient metal, one point in the circumference would be thicker than another point. At times this was so bad that it would burst under pressure, and, of course, this was very unsatisfactory.

We then decided to try brass pipe. Unquestionably, brass pipe has a very long life and is a very satisfactory material. However, we found that it was practically impossible to thread the pipe and get tight screwed joints at all times. This trouble was greater than one would anticipate because, as previously stated, a leak with the service eight feet under the ground and under pavement, presents a

real problem. Finally we came to the conclusion that none of the previously used pipe material was satisfactory. We, therefore, tried copper tubing and have found it the most satisfactory of any material yet used. We now are using copper for all sizes of 2-inches and smaller, and believe that we have solved the problem in securing a satisfactory material, both from the standpoint of long life and from a health standpoint.

Copper tubing can be had at much less cost per foot than the same size in lead, and is made by several companies; therefore, it is readily available at competitive prices. The service connection can be made up of one or more pieces of the copper tubing and the connection to the corporation stop and curb stop, as well as the splices can be made either with a solder wiped joint or a flanged union joint. The various fittings going with the copper tubing can be had from two competitive companies, so there is no risk of paying exorbitant prices.

We have found in St. Paul that due to the greater tensile strength of the copper, fewer breaks are caused by settlement of the ground, especially over a deep sewer trench. Over sewer trenches we have had many breaks in our lead service pipes. However, we have found that the copper, instead of breaking, will pull through the ground and strip the threads from the cast iron pipe. The liability, however, of stripping the threads is much less than the breaking of the lead services.

We have also experimented with freezing of the copper and find that it will stretch sufficiently for at least two times to prevent the pipe splitting. This is also the case with lead pipe. As to its length of life, we have not experimented with it long enough to be able to state definitely that it will last as long as lead. Apparently it is less corrosive and resists solution by water to a very much greater extent and, therefore, we believe that it will have a life at least as long as lead and perhaps longer.

NOTES ON MINNEAPOLIS WATER DEPARTMENT[1]

By C. C. Wilbur[2]

In 1913 the first filter plant in Minneapolis was put into operation with a capacity of 39 m.g.d. By two additions in 1920 this plant was brought to a capacity of 78 m.g.d. This plant is known as the Columbia Heights plant and the source of supply is the Mississippi River. It serves the city by gravity, being approximately two hundred feet above the downtown district. As all the available ground at a suitable elevation has been occupied and its pipe line capacities somewhat exceeded the Columbia Heights property may be considered to have reached its full development in size and capacity.

It was realized some years ago that more additions would be necessary and in 1918 some property was acquired on the east bank of the river about three quarters of a mile north of the city limits and two and a half miles west of the Columbia Heights plant. The development of this property began late in 1923. This is known as the Fridley Plant and is a complete plant with low and high lift pumping stations, filter plant and reservoir. It is laid out for a capacity of 160 m.g.d., the filter units to be built in 40 m.g.d. groups. The pumping station is built on the river bank and contains the low lift pumps raising the water to the filter plant and the high lift pumps for the distribution system. The present filter capacity of 40 m.g.d. has been stretched a trifle this summer and the small reservoir storage of 16.5 million gallons has been practically exhausted very frequently.

With a total filtering capacity in the two plants of 118 m.g.d. our maximum delivery has been 94.5 m.g. These two plants are located near each other and at one end of the city. One is delivering by gravity, the other by pumping. Hence the Columbia Heights plant is in a position to receive water in its reservoir from Fridley if the pressure on the pumps at Fridley is too high. The result has been that raising the pressure at the pumps has slowed up the delivery somewhat from the Columbia Heights plant.

[1] Presented before the Wisconsin Section meeting, August 21, 1930.

[2] Water Department, Minneapolis, Minn.

This condition was, of course, foreseen and steps were taken to eliminate it. The Columbia Heights plant now serves all the consumers on the east bank of the river. The west side of the river demands considerably more water than the east side so the river could not be the dividing line. From the Columbia Heights plant a 36-inch line crossed the river about one mile south of the new plant. This line runs into the west and south districts. A connection to this line from Fridley with a check valve between the new connection and Columbia Heights gave us one outlet. Then a 48-inch steel line following the west city limits and running south slightly over ten miles gave us another outlet. The object of this line was to pump the water under high pressure as far away from the Columbia Heights delivery points as possible before introducing it into the service mains. At the south end of the City we need large storage to take our peak loads. There is no suitable elevation to be found within several miles of the city. This 48-inch main will also serve to feed the reservoir when built.

Our daily consumption of slightly over 100 gallons per capita has reached on several days about 188 gallons and our peak load for short periods has been up to a 316 gallon rate. This means an operatng condition of nearly three hundred per cent over the normal rates. And still we get many complaints of no water, etc.

LAYING A SUBAQUEOUS LINE

One interesting piece of construction was the laying of a 54-inch line under the Mississippi at Fridley. With low water we placed the 750 feet of pipe with the top about two feet under the river bed. A dredge boat with dipper was used to excavate a trench in the sand. A water tight torpedo shaped head was riveted and caulked. A hoist located on the opposite bank then pulled this section ahead thirty feet, when the next section was added and pulled in the same manner. Water was pumped into the pipe to keep the nose down and the pipe at shore end partially buoyant. The current is not swift at this point and a few piles on the downstream side easily held the pipe in position. This line was laid in 14-working days with only one delay. The torpedo nose dug into the bottom once and it required an engine pull computed at 54-tons to break it loose. This pipe showed a low leakage under 200 pound test. It was later unwatered by means of cofferdam, put under test pressure and caulked wherever leaks were found. A shell of 9 inches of concrete was

poured around the pipe. The last section of cofferdam was 250 feet long and was easily kept dry by the use of two 6-inch centrifugal pumps. The material for the cofferdam was mostly sand and silt. It was built up by the dredge boat, care being taken to first remove all bark and dead heads from the bottom.

TREATMENT OF WATER

The water at both plants receives only alum treatment and chlorination. The rice alum at the Fridley plant is received in paper lined box cars. It is stored by use of a pneumatic handling plant taking alum from the cars to either a large storage bin or placing it directly over the dry feed machines in smaller bins. It is also taken in the same manner from the primary storage bin to the bins over the feed machines. This work requires labor only at the suction end and little inconvenience is experienced by the man handling the material. The labor is believed to be a minimum and the method appears to be a success. St. Louis now has a similar equipment.

All our pumps at Fridley are centrifugal pumps driven by 2200 volt, a.c. motors. Power is purchased from the local power company.

Late this year we will have our second filter unit of 40 m.g.d. in operation. We have also just linked the two plants by a steel line from the Columbia Heights reservoir to the Fridley pumping station. This line can take water from the reservoir and by-pass the Fridley plant in case of a shut down, be raised in pressure at Fridley by low head pump or be passed in an emergency through any of the high head pumps at Fridley.

Further developments of the system are contemplated and only require the additional funds to be carried out.

DENTAL DEFICIENCIES AND DRINKING WATER[1]

By R. W. Kehr[2]

From time to time for the past ten or fifteen years various references to a dental defect, known in general as mottled enamel, have appeared in dental literature, and more recently in waterworks literature. Subsequent to the location of several areas in Kansas where the defect is endemic, a survey was made of four of these areas and a questionnaire submitted to members of the dental profession all over the state in order to locate other possible areas. The data collected are submitted in this paper in the hope of arousing additional interest in the problem among waterworks men and sanitary engineers.

Most of the literature available on the subject, although varying somewhat as to details, describes the lesion as being a dead white appearance of the enamel of permanent teeth occurring either in patches or over the entire enamel structure. This was attributed by the late Dr. G. V. Black of Colorado Springs, Colo. to the failure of the cementing material between the rods of the enamel. Later investigations in this field substantiate Dr. Black's conclusions and indicate that the enamel rods themselves may be imperfectly calcified. Normal enamel is translucent and presents a glassy appearance as contrasted with the appearance of mottled enamel which is a dull paper white. In about half of the cases, the normal cementing material is replaced by a vari-colored substance, according to Dr. Black. Structurally the mottled enamel is much weaker than normal enamel, making the proper filling of the tooth difficult, and the teeth are probably in general poorer than normal teeth, although there appears to be some controversy among dentists over this last point. When one considers the health value of well preserved teeth, the importance to the community of seeing that such a condition does not exist is at once manifest, particularly since it is always the permanent rather than the temporary teeth which are affected.

[1] Presented before the Missouri Valley Section meeting, November 6, 1930.

[2] Assistant Engineer, State Board of Health, Lawrence, Kansas.

SURVEY OF DENTAL DEFECTS

The writer's attention was called to the existence of the defect in Kansas by the water superintendent at Chetopa. At the suggestion of Earnest Boyce, Chief Engineer, inquiries were made in the western part of the state where waters of a similar nature are encountered and other affected localities were found. Following this discovery, an examination was made of the teeth of all school children at Chetopa. The data collected was very similar to that of a survey in Colorado made by Dr. G. V. Black. The examination was made by two dentists of Chetopa, Dr. Scott Walker and Dr. Boone, who volunteered their services. Similar surveys have since been made at Utica, Bazine and LaCrosse, by two local dentists, Dr. Frobeck of LaCrosse and Dr. Leiker of Ness City. The data obtained consist of the child's name and age, place of birth, the history of water used since birth, and whether or not the child has mottled enamel. Notations were made as to the teeth on which this occurred, but no attempt has yet been made to compile this material.

A questionnaire was also sent to dentists over the state and the replies received cover the state fairly well. Out of 475 letters sent, 260 replies have been received and it is believed that a number of smaller endemic areas have been found. This questionnaire was written on a single sheet, described briefly the characteristics of mottled enamel, and requested the following information:

1. Have you noticed the above defect?
2. Approximate number of cases—.
3. Do cases appear to come from a certain community? If so where?
4. If this defect is present in your own community, what percentage of native born and raised children would you estimate, roughly, are affected?
5. Do you regard the children's teeth in your own or any surrounding community especially poor? If so, where?
6. If either (3) or (5) are answered affirmatively, what do you regard as the possible cause of the deficiency?
7. Additional information.

Question 4 I found in most cases to be left unanswered, since most dentists do not keep a record of such cases. Question 5 had no value since it requested an opinion and the opinion given was usually about something else. The answers to question 6 were rather scattered,—out of 79 received, 27 blamed the water supplies wholly;

18, defective nutrition wholly; 11, a combination of water and defective nutrition, while the remaining, 23 blamed various combinations of disease, lack of care, water and malnutrition. Out of 246 replies, 100 had apparently never seen a case of mottled enamel, while the other 146 reported from one to more than 100 cases.

The results of these surveys are shown more clearly in the figures shown.

Figure 1 shows the brown stain on the tips of the front teeth, and on one of the upper front teeth is visible a white patch of the uncolored mottling.

The child's teeth in figure 2 show a less amount of stain. The two spots on the front teeth are porcelain fillings.

Figure 3 is a rather unusual case. The two spots on the upper front teeth are pits through the tooth enamel.

These pictures are all of Chetopa school children and the first two are typical cases of mottled enamel.

SOURCES OF WATER

The probable geographical areas where mottled enamel occurs as determined from the questionnaire sent out to dentists, are shown in figure 4. At the lower right is the Chetopa area and in the western part of the state is the large area which includes Bazine and LaCrosse. Surveys of school children in three districts have been made in this area, at Utica, LaCrosse and Bazine. The remainder of the area was blocked out from the denticts' reports. The water supplies in this area are obtained from two sources,—shallow wells, in general striking sands in the Tertiary deposits, which almost entirely cover this district. This water is usually hard and is not always available, and numerous private families and several municipalities drill deeper into the Dakota Sandstone for their supply. This usually provides an abundant and fairly soft, but, in general, a highly mineralized water, and it is the supplies from this water which are under observation as the cause of mottled enamel.

Areas in figure 4 which it is believed are probably endemic for "mottled enamel" are cross-hatched, while areas in which the defect is believed less likely to occur are ruled one way. The distinction between the two is small and was largely determined by the number of different dentists reporting the area and the details given by the dentists. The notations in the blank spaces in each area are the places from which these areas were reported, and the number of

FIG. 1

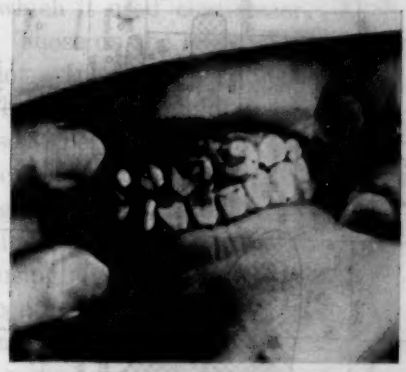


FIG. 2

FIG. 3

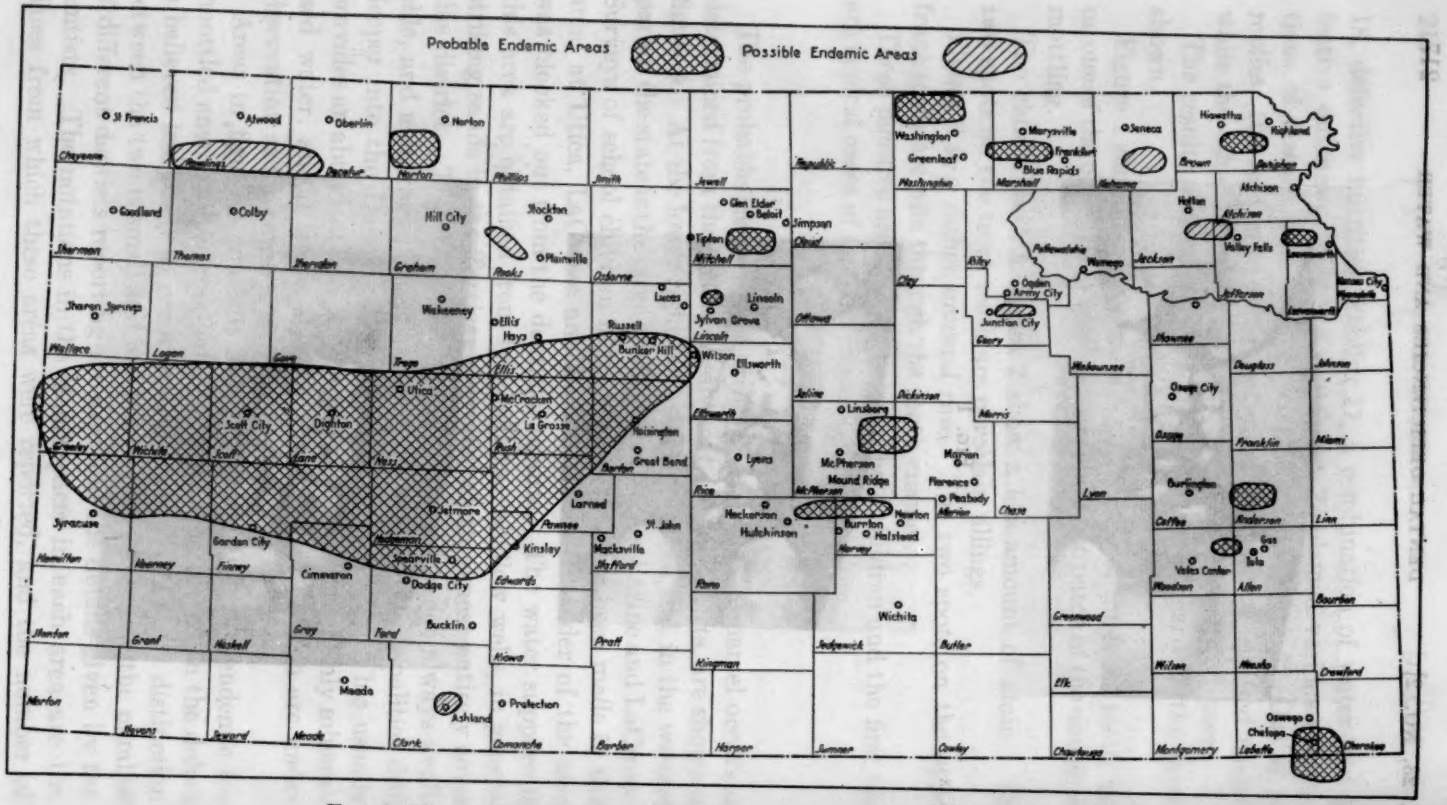


FIG. 4. MAP OF KANSAS SHOWING AREAS REPORTING MOTTLED ENAMEL

dentists reporting. For instance, in the district northeast of McPherson, 4 dentists from McPherson reported the area, while the Chetopa district, a known endemic area, was reported from Coffeyville, Oswego (2), Chetopa and Pittsburg. With the exception of the large area in western Kansas, the boundaries outlined on the map do not indicate the probable extent of the affected area, since in nearly all cases this is entirely speculative at present. The Chetopa area obtains its water from the Mississippian formation, which is supposed to have a catchment area in the Ozarks in southwestern Missouri and northwestern Arkansas.

Figure 5 is a graphic record of the school children at Chetopa and the length of their life during which they drank city water. Starting at the bottom and reading upward, the years of the child's life is noted during which it used city water. Each line represents a child examined. Those on the left had mottled enamel while those on the right did not. In addition to the ones who had had city water in their homes, there were 90 children who used city water only at school and of these 88 percent were not affected. The percentages of affected children can be seen more clearly in figure 9.

Figure 6 is a graph of the LaCrosse survey similar to figure 5. The dotted lines indicate the children using deep well water and the solid ones those using city water. This does not show as clearly as figure 5 the percentage of children affected, but considering only the solid black lines, the graph is similar to figure 5. The difficulty in obtaining the same accuracy with deep well water as with city water taken from a known stratum is that the information requested from the children regarding their water supply was whether or not they used city water, a deep well, a shallow well or a cistern. From this sort of question, there would obviously be many discrepancies when the information desired was whether or not their well drew from the Dakota sandstone formation, which is tapped in known wells at depths ranging from 200 to 800 feet and probably varies over a considerably greater range than that.

Figure 7 shows the results of the Bazine survey. This is of interest largely because it is the only district surveyed which had no city water supply. The private wells at Bazine are largely shallow hard water and this shows up in the smaller percentage of cases of mottled enamel. Two analyses were made of the water from deep wells in and near Bazine, both of which had apparently affected the children's teeth.

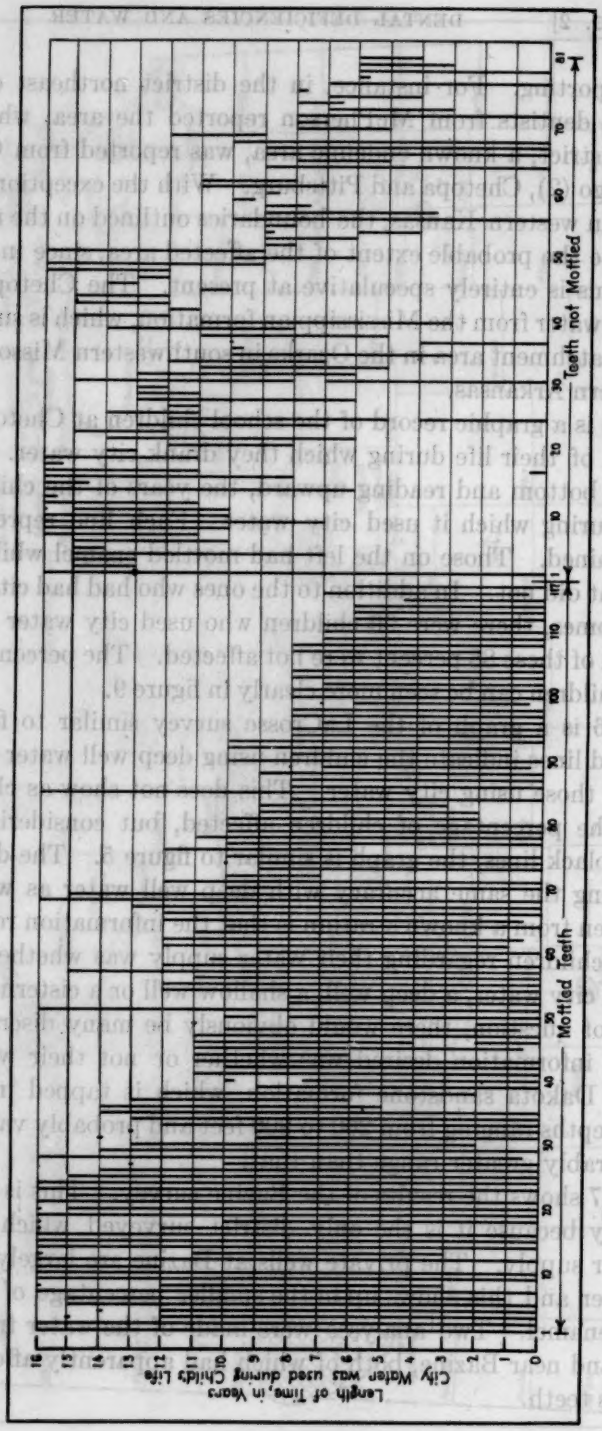


FIG. 5. STUDY OF MOTTLED ENAMEL. CHETOPA, KANSAS, SCHOOL CHILDREN, MAY 20, 1930

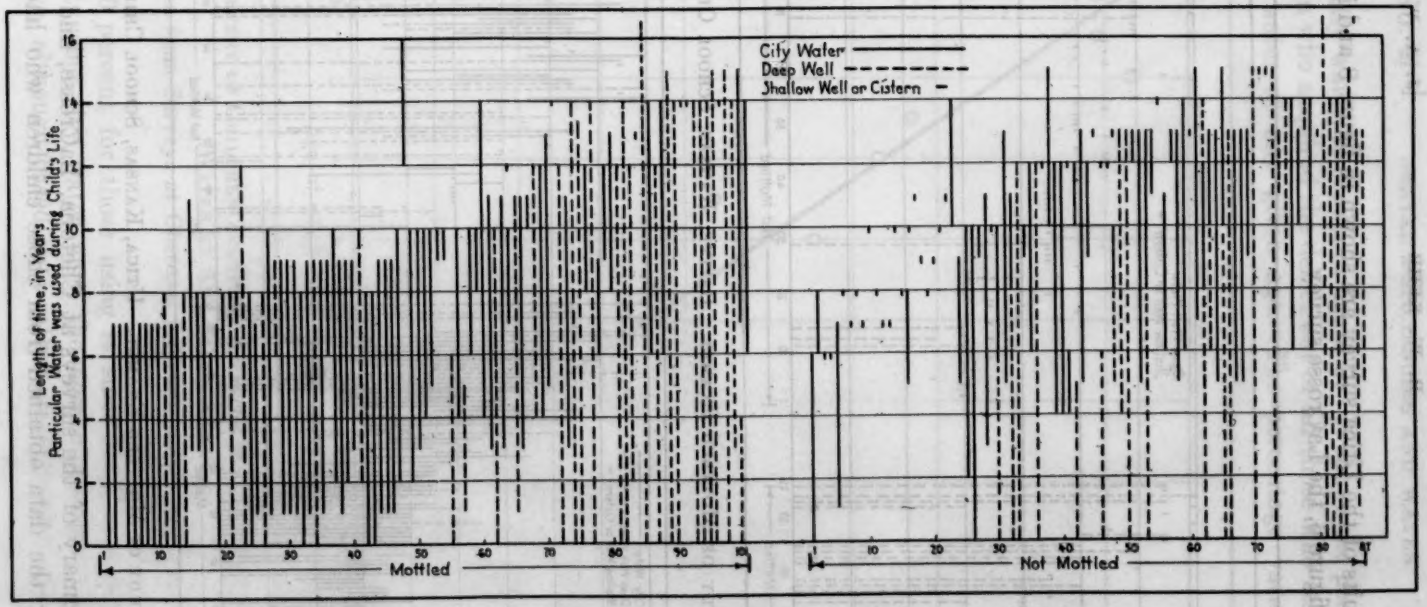


FIG. 6. STUDY OF MOTTLED ENAMEL. LACROSSE, KANSAS, SCHOOL CHILDREN

The results of the Utica survey are shown in figure 8 and is quite similar to figure 6, the LaCrosse survey.

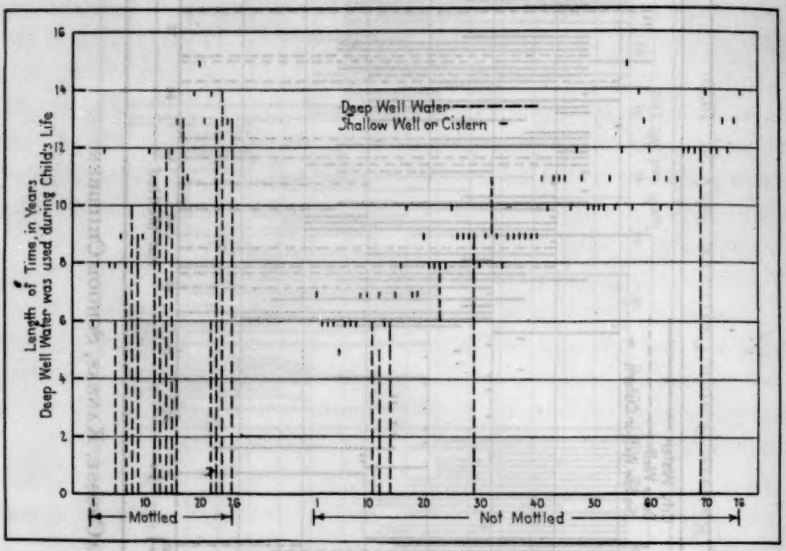


FIG. 7. STUDY OF MOTTLED ENAMEL. BAZINE, KANSAS, SCHOOL CHILDREN

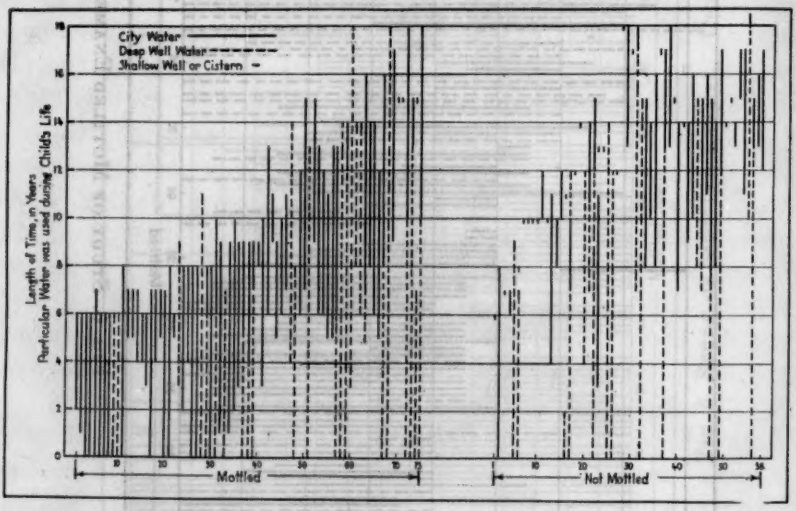


FIG. 8. STUDY OF MOTTLED ENAMEL. UTICA, KANSAS, SCHOOL CHILDREN

The summary of the surveys at Chetopa, LaCrosse, and Utica, using only the data obtained from those children who had been

drinking city water, is shown in figure 9. It shows the percentage of children who acquired the defect out of all those who started to use city water at any given age. The percentage varies from

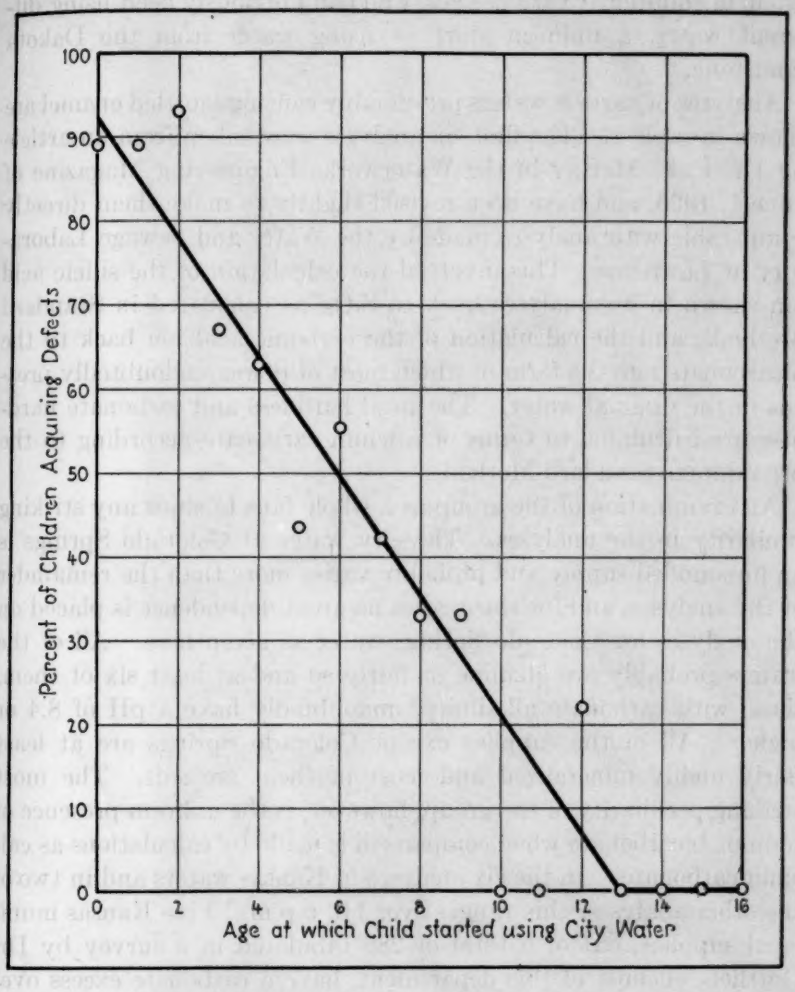


FIG. 9. PERCENT OF CHILDREN ACQUIRING DEFECTS WHO BEGAN USING CITY WATER AT ANY GIVEN AGE

(Data from Surveys at Chetopa, LaCrosse and Utica, Kansas)

around 90 percent for those using it since birth to 0 percent for those not using city water until the ages of twelve to fourteen. This curve, although based on a rather small number of children,

should be fairly accurate due to the adaptability of the material gathered to this type of curve, i.e., both LaCrosse and Utica started to use their present supply of water eight years ago and this gives a group of children at various ages, who had previously been using different water, a uniform start at using water from the Dakota sandstone.

Analyses of various waters presumably causing mottled enamel are shown in table 1. The first six analyses were taken from an article by Dr. F. S. McKay in the Waterworks Engineering Magazine of June 1, 1926, and have been revised slightly to make them directly comparable with analyses made by the Water and Sewage Laboratory at Lawrence. This involved the calculation of the silicic acid ion shown in his analyses back to SiO_2, as calculated in Standard Methods, and the calculation of the carbonic acid ion back to the bicarbonate ion, the form in which most of it was undoubtedly present in the original water. The total hardness and carbonate hardness are calculated in terms of calcium carbonate according to the precedure in Standard Methods.

An examination of the group as a whole fails to show any striking similarity in the analyses. The city water at Colorado Springs is an impounded supply and probably varies more than the remainder of the analyses, and for this reason no great dependence is placed on the analyses for Colorado Springs water as given here. All of the waters probably are alkaline or fairly so and at least six of them, those with carbonate alkalinity, undoubtedly have a pH of 8.4 or higher. All of the supplies except Colorado Springs are at least fairly highly mineralized and most of them are soft. The most striking peculiarity of the group, however, is the uniform presence of sodium bicarbonate when comparison is made by calculations as calcium carbonate. In the six analyses of Kansas waters and in two of the other analyses, this ranges over 140 p.p.m. Five Kansas municipal supplies, out of a total of 289 tabulated in a survey by Dr. Gottlieb, chemist of this department, have a carbonate excess over total hardness of 140 p.p.m. or greater. Three of these supplies are located in proven endemic areas. This is an interesting fact and is mentioned only as such. Tending to disprove this as a possible cause is the fact that in all probability mottled enamel does not occur in the other two towns.

Examining the excess carbonate hardness from the chemical standpoint, we find that the calcium, magnesium, and carbonate hardness

TABLE 1

Water analyses from endemic districts

	TOTAL SOLIDS	SiO_2	Fe^{+++}	Al^{+++}	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	SO_4^{--}	Cl^{-}	NO_3^{-}	TOTAL HARDNESS	CO_3 HARDNESS	EXCESS CO_3 HARDNESS
*Oakley, Ida. warm spring	308	78	0.06		2.7	0.90	84		19	69	26	52	0.23	10	88	78
*Mine water, Pictou, Colo	1,429	10.9	0.90	2.7	90.0	27.4	277		—	440	651	47.4	—	337	361	24
*Mine water, Chandler, Colo	571	—		trace	74.4	16.7	37.1		—	486.4	104.7	14.2	—	254	399	145
*L. Ranch well water, Louisville, Colo	1,091	14.1	—	—	31.8	37.8	207.8	3.4	—	1,248	142.4	31	—	234	1,023	789
*S. family well at Lafayette	1,169	11.7	—	3.4	33.3	33.6	242.7	6.4	—	1,076	250	51	—	211	882	671
*City water, Colo. Spgs.	58	4.9		0.5	5.7	1.7	3.2		—	31	7.1	7.3	—	21	25	4
Chetopa city water	864	6.2	0.2	5.42	11.6	4.6	312.2		9.6	469.0	9.9	235	—	47	401	354
LaCrosse city water	1,309	30.6		3.2	13.2	9.8	465		9.6	278.5	228	427	—	72	244	172
Utica city water	1,003	9.4		2.2	9.0	4.4	370		14.4	346.5	164	258	—	40	308	268
Ness City private well	792	6.8		2.2	13.6	6.8	279		8.4	233.0	172	202	—	62	205	143
Bazine private well	794	8.6		3.4	16.8	6.2	266		7.2	263.5	166	174	—	67	228	161
S. E. of Bazine priv. well	1,125	9.4		2.6	20.4	12.6	377		0	319.6	236	294	—	103	262	159

* Analyses from article by Dr. F. S. McKay, Waterworks Eng. (1926), revised by Dr. Selma Gottlieb, Chemist, Division of Sanitation, to correspond to routine laboratory reports so that comparable analyses are obtained.

are accurately determined, as well as the potassium in some cases, while in most cases the sodium is calculated to be present in sufficent quantities to balance the plus and minus ions, which means that any mistake made in the determination of sulfate, chloride, nitrate, carbonate, bicarbonate, calcium or magnesium, would affect the results calculated for sodium and potassium. The ordinary elements not tested for routinely would be precipitated by one of the reagents added in the ordinary routine analyses and would appear as iron, calcium, etc. or would carry through and be calculated as sodium. The presence of another member of the sodium group might explain the high sodium content, although this seems hardly plausible. At any rate, we have 12 analyses of endemic waters, 10 of which are calculated to have at least a fairly large amount of sodium bicarbonate and, with this in mind, it would seem advisable, in the case of a new water supply for a city, to make an investigation of the teeth of children who are using this water, providing the water is of the type containing calculated sodium bicarbonate. This would not be applicable in many cases, since many proposed supplies are not previously in use by private families, and also a water of this type is under consideration comparatively infrequently, but the proposal is mentioned since it might be of value to someone and the expense of such an investigation as an adjunct to the chemical analyses would be slight.

WATER SUPPLY AND MOTTLED ENAMEL

In covering briefly the causes which have been brought forth in the past to explain the phenomenon of mottled enamel, the water supply appears to the writer to be the most likely of all which have been suggested. The practically 100 per cent occurrence among those using a water supply as against a similar percentage of freedom for those not using the water supply, but living in the same locality, is almost inexplicable by any other hypothesis. The localization of the defect in areas entirely apart from the centers of population of a given area is also hard to explain by any other reason. For instance, if disease or malnutrition were the cause of the defect, how could one explain the fact that Kansas City, Wichita, Hutchinson, Topeka, Salina, in fact all of the larger cities of Kansas, are free from the defect? In each of these towns numerous dentists reported no cases from that area. Among the poorer classes of people in those towns are many families that undoubtedly have a lower standard of living

than the average family in the endemic towns. The diseases of childhood which are given as the cause in an article by Carl Fossum, D.D.S. apparently bear no relation to the case records of such diseases for areas where the defect is endemic, and areas free from it. This is illustrated by table 2, giving the total case rates per 1000 for six years, 1920 to 1925, for the following cities reported non-endemic for mottled enamel: Kansas City Kansas, Wichita, and Hutchinson, and the endemic areas, Rush County and Ness County.

Excepting the whooping cough rate for Hutchinson, the diseases are equally, or more, prevalent in the given non-endemic areas than in the endemic ones.

Nutrition probably plays its part in the causes of mottled enamel, since the food supply and the water both contain minerals which are

TABLE 2

Cases 1920–25

AREA	POPULATION	MEASLES		WHOOPING COUGH		TYPHOID FEVER	
		Cases	Cases per 1,000	Cases	Cases per 1,000	Cases	Cases per 1,000
Rush County	8,781	177	20.4	114	13.0	Not reported	
Ness County	7,636	127	16.6	66	8.6	17	2.2
Kansas City	116,000	4,791	41.3	1,783	15.4	240	2.1
Wichita	88,000	4,924	40.0	1,662	18.9	396	4.5
Hutchinson	26,000	804	30.9	141	5.4	128	4.9

taken into the body. This is the interpretation which the writer would place upon work done by the American Dental Association, and more specifically upon the results obtained by Pierle, research dentist for the American Dental Association, in producing a condition similar to mottled enamel in the teeth of guinea pigs when placing them on a diet low enough in the necessary food elements to produce a rachitic bone structure also in the animal.

The presence of manganese, suggested in past literature as a possible cause, was not found in two analyses made on waters from an endemic area and in the only two others analyzed was found to the extent of less than 0.1 and 0.25 p.p.m.

ACKNOWLEDGMENTS

A complete recent bibliography on the subject of mottled enamel has been compiled by Dr. Frederick S. McKay, and is published in

the *Journal of Dental Research*, Vol. 10, for October, 1930. The writer has drawn freely from a great many of the references given there and in some cases, unintentionally, has probably taken material without giving due credit. If such has happened, it is sincerely regretted. For assistance in this work, the writer wishes to thank the dental profession in Kansas and especially Dr. F. O. Hetrick, Chairman of the Research Committee of the American Dental Association.

It is planned to continue the investigations in Kansas and in the course of the next year most of the suspected endemic areas will probably have been visited. More definite information should be available at that time.

DISCUSSION

ABEL WOLMAN:[3] The peculiar condition of the teeth described by Mr. Kehr and termed "mottled enamel" has been the subject recently of extensive study by the U. S. Public Health Service. The significance of the study to water works officials is so great that I am taking the liberty of adding at this point a summary of the findings of the Public Health Service. The detailed study appeared in Public Health Reports, 48: 48, November 28, 1930, as presented by Grover A. Kempf and Frederick S. McKay. The summary is as follows:

> The dental defect known as mottled enamel occurs in various parts of the world, notably in Italy, certain of the Bahama Island, Barbados, Holland, Cape Verde Islands, China, Mexico, Spain, Argentina and other South American countries and in South America. Wherever it occurs the characteristics of the enamel defect are the same.
>
> The chief injury caused by this condition is the discoloring of the teeth. The teeth are of normal form, but not of normal color. When not stained brown or yellow, they are a ghastly opaque white, which is noticeable whenever the lips are opened. In many cases the teeth appear black. The typical brown stain cannot occur unless the enamel bears the fundamental mottle defect; but not all teeth with mottle enamel are stained.
>
> It is readily understood that this condition is a problem worthy of solution when it is sealized that every child born and reared in an area in which it is prevalent is practically certain to bear this disfigurement in some degree.
>
> A study was carried on by the Public Health Service in an area in which this condition occurs. This area centers in the town of Bauxite, Ark.
>
> The facts gathered in this survey indicate that there is a specific agent or condition in the environment of the village of Bauxite which interferes with the

[3] Chief Engineer, Maryland Department of Health, Baltimore, Md.

development of the enamel of the permanent teeth. This agent or condition is strictly limited to the village, which has a common source of water supply. Children in the immediate vicinity of the village are not affected.

It does not seem probable that this agent is in the food, because the mode of life and the diet of these people are the same in the village as outside it. It attacks the children of rich and poor alike. Physical condition seems to be of no importance. As far as can be seen, the only common factor is the use of water from a central well.

No definite conclusions can be deduced at the present time other than that this enamel defect occurs in certain areas of the United States, and the causal factors seem to be definitely associated with the water supply of these areas. Exposure of a child, during permanent enamel growth, to the environmental factors in an endemic area appears almost certain to result in the development of mottled enamel.

RECLAMATION OF TREATED SEWAGE[1]

By R. F. Goudey[2]

Reclamation of sewage in Southern California is coming whether we like it or not. It is not a question of sewage disposal, but one directly related to a legitimate increase in water supply. In fact, reclamation of treated sewage is diametrically opposed to sewage disposal as it is universally practiced. Since the waterworks man alone is responsible for the safety of water it is fitting that he dictate the method of reclamation and control its operation.

There is no need for the waterworks man to fear public criticism, even though sewage is generally considered unclean and repulsive. The prejudice and superstition which the public is supposed to have against "sewage" is readily dispelled by a proper presentation of the subject. Waterworks men actually jeopardize their position unless they make a complete "right about face" and adopt sane and sensible viewpoints on the subject.

The Bureau of Water Works and Supply of the City of Los Angeles, under the direction of H. A. Van Norman, Chief Engineer and General Manager, and Carl Wilson, Director of Sanitation, has for several years been conducting a comprehensive study of reclamation and for the past six months has been actually demonstrating on a working scale that sewage can be treated with adequate safety and be reclaimed without offense. It is interesting to note that not one of over five hundred visitors to the plant has voiced any criticism of it and all have apparently been impressed with the feasibility of reclamation.

California likewise need have no fear of eastern criticism, for it is in the east where one finds the most primitive methods of reclamation being practiced with no thought of their being questionable or repulsive. What else is it than reclamation where city after city discharges crude sewage into streams used by cities below for water supply intakes. But it is uncontrolled and unreliable reclamation. In some cases these rivers become veritable sewers and yet by heroic

[1] Presented before the California Section meeting, October 30, 1930.

[2] Sanitary Engineer, Department of Water and Power, Los Angeles, Calif.

operation of treatment plants, which are taxed far beyond what is proposed in sewage reclamation, they actually produce acceptable water. Had California been endowed with running streams the same method as used in the east would probably be in vogue here.

THE PRINCIPLES OF SEWAGE RECLAMATION

Reclamation of sewage involves: first, the correct or proper type of installation, and second, a tone of operation far excelling that common to sewage treatment plants. The underlying principle of sewage disposal is to use that type of treatment works which just barely meets minimum standards. Too often it is but a temporary makeshift incapable of doing creditable work. The records of over fifty sewer farms and as many sewage treatment plants in this state, where nuisances and menaces to health exist, bear out this observation. The sewage treatment plants, with but one or two exceptions, are neglected, improperly operated and financially unsupported. Most of the plants are sloppily cared for and are not given the chance to perform what the designer had planned. In reclaiming sewage adequate facilities allowing for great flexibility in operation should be taken into account. The plant, instead of being operated on a shoe string basis, should not only be intrusted to thoroughly trained operators, but should be backed up with high grade, technical supervision. In short, sewage treatment is thus taken out of the gutter and placed on a scientific and business-like basis. Shorn of its disgrace, so far as sewage disposal is concerned, it loses its shocking, false and startling reactions and in reclamation becomes a natural and logical step borne of necessity and expediency.

Among other things reclamation must take into account various credits and debits which are involved in its various minor ramifications. Its economic aspects are far reaching. For instance, reclamation should be credited with saving in the maintenance, depreciation and operation of outfall sewers and displaced treatment works, the saving of additional outfall sewer and treatment capacity needed in the future, revenue or credit from sale of fertilizer, recovery of power from gas collected in the separate sludge digestion process, the fertilizing value in the treated water and, finally, the cost of water treatment works necessary to bring up the quality of the water supply to that of the treated sewage. Naturally the costs of pumping, transportation, storage and distribution of that portion of the treated sewage actually reclaimed should be taken into account.

THE METHODS OF RECLAMATION

The possible methods of reclamation which the Department is studying include: complete treatment for direct augmentation of reservoir supplies; replenishment of underground water supplies with sewage treated to the proper degree for the different spreading grounds under consideration; substitution of treated water for irrigation supplies; utilization of treated sewage for the development of new agricultural areas and production of a water suitable for various industrial purposes. Any of these methods can be carried out far more safely and with less psychological objection than is the case with the cruder methods of reclamation of the east.

The present study at the reclamation plant of the Department is that of replenishing ground water levels above infiltration gallery locations. This method of reclamation has very distinct advantages over discharging untreated sewage into rivers used for domestic supply in that the sewage, in the first place, is given high grade sewage treatment before discharge onto beds; second, the natural purification in sand beds and through underground journeyings is far greater than provided in the natural self-purification of rivers; third, the identity of treated sewage is annihilated more effectively; fourth, dilution is far greater; and, fifth, the time of travel instead of being measured in days is increased to many months.

The question may properly be asked, why should completely treated sewage, which far excels the standards of most waters used for domestic purposes and whose purity is known with absolute certainty, be discharged onto sands and be allowed to pick up foreign material and lose its high quality. The water could more safely be used as it is. Although this complete treatment involves skill in operation, it is no more exacting than other technical functions in civilization which have become commonplace. The possibilities of reclamation are increasing as the subject is investigated and at this time no conclusions can be drawn as to the recommended method.

NEED FOR RECLAMATION

Many have been the attempts in the past to establish civilizations in arid or desert regions. It is significant that all have failed because of inadequate water supplies. Will Southern California meet the same fate? It is a direct challenge.

The water situation in Southern California is really tragic. Although the city of Los Angeles has its problem well in hand, the do-

mestic and agricultural needs have been increasing at a greater rate than has the importation of outside water. As a result, underground water supplies which should be held for emergency use, or, at least, should not be called upon for continued excessive draft, have not only been dangerously overdrawn, but in some areas have actually been depleted. We are trying to "get by" as Mr. Harold Conkling, Deputy Engineer, State Division of Water Resources, puts it, with 2,500,000 people, or over one-half of the population of the State, in one and four-tenths percent of the area of the State and in which only seven-tenths of one percent of the water supply of the State is produced. Already an artesian area of 45 square miles has become saline and in the past few years the water table over an area of 162 square miles has been lowered below sea level. In some of the best inland citrus belts water is dropping out of reach and the orange growers there are duly alarmed. In Orange County water levels during the past 15 years, which period included a number of years of heavy rainfall, have dropped over 120 feet and the orange growers are starting to sit up and take notice. Just as soon as agricultural interests are hampered for adequate water supplies right then will prosperity cease and a continuous train of serious setbacks be set in motion. It will take less than one waterless year to put any orange grove back to the desert. In fact, even in the city it will take but one year of restricted use to kill most of the lawns and shrubbery around our homes.

The underground basin of the South Coastal Plain, as it is called, must be replenished at once to stop the inroads of salt water invasion, and thereafter not be overdrawn. Conservation of flood waters and reclamation of treated sewage represent the two most available sources of water for this purpose.

The present volume of sewage discharged into the ocean is 160,000 acre feet per year. This volume of water is 50 percent greater than the combined salvable flows of the Los Angeles, San Gabriel and Santa Ana Rivers. In fact, the present sewage flow is one-tenth of the total long period precipitation on the entire south coastal plain. Sewage is easier to conserve than flood waters because flood flows are flashy, erratic, uncertain in volume, difficult to desilt, dangerous from a bacteriological standpoint and require extensive works which for the greater part of the year are idle. The volume of flood waters is not likely to increase in the future. Sewage, on the other hand, represents a definite steady flow which increases with the increase in

population, can be economically and efficiently treated and requires the minimum effort, equipment and expense to conserve. With a three fold increase in population the sewage flow will be five times greater than the salvable flood flow in the same area.

Conservation of flood waters is of secondary importance to the chief function of flood control, which is protection of life and property. Naturally its waters should be conserved. To place flood control solely on the platform of conservation makes the cost of underground water replenishment all out of proportion to the much cheaper method of sewage reclamation. For instance, reclamation at Puddingstone, which is the best example of cheap storage, requires an outlay of $2,500,000 to conserve 5.63 second feet. In sewage reclamation the installation cost plus the gross cost of operation capitalized is $600,000 for the same yield. The sewage flow offers the largest increasing volume of water as the easiest and safest to conserve.

Even after all outside sources of water are fully developed, including the Colorado River and Mono Basin, there will still be a deficiency to meet the ultimate domestic and irrigation requirements of the population which this area is otherwise capable of supporting. Only one-half of the water supply reaches the sewer system, making it evident that sewage alone cannot be called upon to maintain a constant permanent supply. Reclamation is an integral part of the Colorado River project and both should go hand in hand.

Not only is reclamation of treated sewage practical at the present time for the immediate relief of overdrawn underground water basins but is "an ace up the sleeve" to tide over any undue delays in securing Colorado River water, and also fits in as a necessary cog when all distant sources have been developed. There can be little wonder, therefore, why this community, which should be the first to conserve, and which has been vieing with the world in the construction of the longest sewers to waste sorely needed water, has of recent months turned attention seriously to reclamation.

SEWAGE AND SEWAGE TREATMENT

Many people have the "specialist" idea of sewage reminiscent of earlier days. In the modern water carriage system the human wastes are automatically diluted 2500 times with water. Such sewage at its worst is 99.96 percent water. It is the dirtied water supply and is a by-product of the waterworks just as power is a by-product where

it is developed from water supply. Power instead of being wasted is commercialized. Sewage has the same possibilities.

Nature has been reclaiming used water and for countless eons has been returning it for re-use. Reclamation simply speeds up this natural function. It uses Nature's forces of self-purification, improves and harnesses them under laboratory control where the entire cycle is accelerated. By laundering the sewage to remove dirt and dangerous material, clear, clean and safe water can be produced. When one's shirt becomes dirty it is washed instead of being discarded. Why not the same with sewage?

Water and sewage have been blamed by the layman as the cause of every existing disease and yet only a few of the almost obsolete diseases such as typhoid, para-typhoid, dysentery and cholera are water-borne. Water purification as now developed affords ample protection against them. Sewage purification even of mediocre types gives complete and positive protection against pathogenic organisms and in no instance has any epidemic been traced to the effluent from any so-called high grade sewage treatment plant. Certainly combinations of sewage treatment and water purification give ample factors of safety ensuring positive protection to public health.

That sewage itself can be completely treated for domestic purposes is witnessed by several cities on the Ohio River and a number along the Ruhr River in Germany, where, during low river stages, more water has been diverted than present at normal dry weather flow because of the added increment of sewage. During these periods the bacterial count of the raw water has been identical with crude sewage. Yet, in these cases water purification plants alone produced water complying with the United States Treasury Department standards, even though the raw waters were far inferior to the effluents from high grade sewage treatment plants.

Each scheme of reclamation requires its own degree of sewage treatment and in no case should the present policy of putting in plants to just "get by" and meet minimum standards be tolerated. Likewise, all uncertain steps in treatment should be fully worked out and only that type of plant which really meets all requirements should be constructed. No one has developed this phase of reclamation and the Los Angeles Bureau of Water Works and Supply pioneered by placing in continuous operation, on May 12, 1930, a model sewage treatment plant purposely designed really to treat sewage, work out refinements and overcome many hitherto unsolved steps in

treatment. The plant is particularly designed to use mechanical equipment to the greatest possible extent, to simplify and reduce the cost of operation and to carry treatment further than ever before attempted by anyone. This plant is experimental only insofar as improvements in sewage treatment are concerned, but it is a demonstration working plant to determine accurate costs both of installation and operation in the actual successful reclamation of sewage. It is the first installation on a working scale of a high type of treatment plant which is continuously producing from sewage a safe drinking water strictly complying with and even exceeding all standards. Samples of water in long Nessler tubes have less color and turbidity than distilled water and actually have a more sparkling appearance. These statements are not based on talk or theory, but are of actual accomplishment.

DEMONSTRATION OF SEWAGE TREATMENT AND RECLAMATION

The sewage purification plant operated by the Department of Water and Power of Los Angeles consists of four stages of treatment:—clarification, stabilization, filtration and spreading on disposal beds. Clarification and disposal of sludge takes place in a separate sludge digestion plant; stabilization occurs in an activated sludge plant; filtration is secured by chemical coagulation, sedimentation, sand and carbon filtration; and final disposal is on sand beds where ground water is replenished. The capacity of the entire plant is 200,000 gallons per day except for the filter plant which is one-third of that amount.

The separate sludge digestion plant settles the crude sewage in Dorr clarifiers for two hours, removing settleable and floating material. The fresh sludge and concentrated excess activated sludge is pumped to a covered and heated digestion tank where all solids entering the plant finally succumb to gasification, liquefaction and humification. The digested sludge is removed onto drying beds and produces when dry, a fertilizer of about the nitrogen content of barnyard manure. Experiments with conditioning and vacuum filtration of digested sludge indicate that in the future there will be no need for any sludge drying beds. Overflow liquor, a serious problem in plants of this type, has been reduced over 85 percent in volume by concentrating sludge before pumping it to the digestor and withdrawing digested sludge simultaneously with the pumping in of new sludge. Gas evolved in the process is used for power development

and engine cooling water is employed in heating the digestion tank. It appears that sufficient power can be developed to operate the entire activated sludge plant, greatly reducing its cost of operation.

The settled water passes to the activated process which removes practically all suspended matter and produces a fairly clean clear and odorless water. The procedure is that of adding activated sludge to settled sewage and after aerating the mixture for a proper period it is allowed to settle. The biological life and colloidal characteristics of the activated sludge are such as to remove colloids and suspended solids after prolonged intimate contact so that when the sludge is permitted to settle clear water overflows at the top. The settled sludge is re-circulated continuously and when an excess is built up it is intermittently withdrawn for disposal in the separate sludge digestion plant.

The aeration tanks are equipped with Imhoff paddles which effect large savings in compressed air ordinarily used at such plants. Experiments with various percentages of sludge return, aeration and re-aeration periods, multi-stage treatment, double sedimentation and an addition of enzymes are under way and it is already indicated that better than customary performances can be obtained at less than the usual cost of operation.

The filtration plant consists of:—super-chlorination, with Wallace and Tiernan equipment to remove phenols and odors and to oxidize organic matter; coagulation with ferric chloride and returned sludge in mixing tanks to remove iron, color, turbidity and any traces of hydrogen sulphide, if present; sedimentation, to remove the greater portion of the settled floc; filtration through sand, to produce a clear water; and, finally, filtration through Darco activated carbon to remove residual chlorine and any final color. Experiments include proper mixing methods for ferric chloride, revision of filter equipment using manifold jet inlets for influent, 10–12 inches sand depth, sand with an effective size of 0.9 m.m., surface backwash and return of sludge. The experiments were made necessary to adapt filtration to the advantages which ferric chloride possesses over alum in filtration of this type of water.

The spreading grounds are five in number and are used both continuously and intermittently. By using chlorine one bed has been in continuous use for over three months. Rates of filtration up to one million gallons per acre per day appear feasible. Fourteen 2-inch wells have been driven in and around the disposal beds to test

the quality of water after both downward and lateral filtration. Ground water stands about 25 feet from the surface. At the present time the 200,000 gallons of sewage reclaimed daily has no effect on the ground water as it is diverted from one of the main galleries of the City located one and one-half miles downstream.

A fully equipped laboratory has been provided specifically for sewage reclamation and composite samples from various stages of the process are collected daily for complete sanitary chemical analysis. Averages for several hundred samples on a few of the most important tests are given in table 1.

TABLE 1

Chemical results—water reclamation plant

CHARACTERISTICS	SEWAGE CRUDE	TREATED SEWAGE			LOS ANGELES WATER UNTREATED		PERCENT REMOVAL SEWAGE TO FULLY TREATED SEWAGE COMPARED WITH L. A. AQUEDUCT
		Settled	Stabilized	Fully treated	Aqueduct	Gallery	
B. coli per (1) cc	100,000	50,000	1	0.00	0.05	0.00	100+
Suspended solids, p.p.m.	418	77	3.2	0.0	6.0	0.0	100+
Turbidity, p.p.m.	440	—	8.3	0.2	25	0	100+
Oxygen demand, p.p.m.	515	222	9.1	0.99	1.25	1.0	100+
Oxygen consumed, p.p.m.	180	46	8.3	4.1	3.5	1.2	99.7
Organic nitrogen, p.p.m.	48.1	37.3	5.08	2.25	1.3	0.5	99.8
Free ammonia, p.p.m.	50	20	1.0	0.65	0.25	0.20	99.2
pH	6.8	6.6	7.0	7.1	7.3	7.2	—

The analyses in table 1 clearly demonstrate that the treated sewage is better than aqueduct water and about the same as gallery water. Minerally the treated water is just as acceptable. These tests include analyses of samples taken during the peach and tomato packing period when the plant handled the wastes from 150 tons of peaches packed per day. During a month of this period the settleable solids averaged 600 p.p.m. and the B.O.D. was over 800 p.p.m. The entire plant was put to a severe strain and the results above given are on this account all the more remarkable. During the winter season analyses will probably show the quality of the fully treated sewage water to be equal to or better than gallery water. Furthermore, it has only been during October that any attention has been

given to the filtration plant in order to get more efficient results. The removal of 99.2 percent of free ammonia means that there is left in the treated sewage less than 0.05 ounces of nitrogen for each 1,000 gallons. In 12 hours time the raw sewage becomes a good water with no B. coli in 50 cubic centimeters, with a turbidity and oxygen demand of less than 1, and no trace of suspended solids. Upwards of 300 of the 500 visitors to the plant have tasted the treated water and many have drunk it liberally without any disastrous effects.

Accurate records are being maintained in order to determine the costs of plants of 1, 10 and 25 m.g.d. designed on the same basis of operation as the demonstration plant. The costs for the larger plants are determined after a complete and detailed design has been made enabling the depreciation and maintenance of the smallest piece of equipment to be figured. The installation cost for a 25 m.g.d. plant, including separate sludge digestion, activated sludge and chlorination is $1,500,000. The cost of adequate operation including power, labor, chemicals, depreciation, maintenance, research, miscellaneous items and contingency is 1.5 cents per 1000 gallons. The installation cost and operation of the filtration units has not yet been fully worked out. The added installation cost may be $10,000 per mg. capacity and the operation might reach 0.5 cent per 1000 gallons. It is interesting to note that the net cost of treating sewage at Pasadena, exclusive of interest and bond redemption, is 4 cents per 1000 gallons. The cost of ocean outfall maintenance and adequate treatment for ocean disposal is 1.5 cents per 1000 gallons. These figures do not include interest or bond redemption which, for reclamation, would be less than 1.5 cents per 1000 gallons.

A complete description of this experimental plant is given in Western Construction News for October 25, 1930.

RECLAMATION

At the present time the actual demonstration by the Department of Water and Power of Los Angeles is the replenishment of ground water, simply because it works in with the experiments on sewage treatment.

Reclamation is a problem of great magnitude in which a number of difficulties have to be overcome. In the September 25, 1930, issue of the Western Construction News is an outline of the Department's

program on conservation of treated sewage. It involves many lines of investigation and it would be premature at this time to outline and publish cost summaries of schemes which have already been worked out. It is felt, however, that a good start has been made on a problem so important to the future welfare of Southern California.

THE COST OF RENDERING PUBLIC FIRE PROTECTION SERVICE[1]

By Edward B. Mayer[2]

There has been so much presented to the Association on this subject that another paper hardly seems necessary. Yet, notwithstanding the progress made in the practice, clear understanding of and definite decision as to how much will be charged for public fire protection service are still lacking.

Most discouraging is the information that some of our larger cities are discontinuing the practice of making a charge for public fire protection. This simply means one thing; that it is the result of political influence, which clearly brings out two points necessary for decision. First, what is a proper charge for fire protection, and second, what line of attack should be made to improve conditions?

If we are going to consider the problem as it affects the water works, we must drop the idea of "hydrant rental." This term was originally only a means of levying a charge for revenue, but it has done more than that, it has shortened the viewpoint of the public and public officials, by conveying the idea that merely installing a fire hydrant on an already existing water main is all there is to providing an adequate supply of water for fire protection.

The operations of water works are not capable of much standardization, except in a general way, because of the variety of conditions under which the plants function. It is an established principle in the operation of public utilities of the present day that the charge for a service should be commensurate with its cost. However, due to various other economic conditions, unit costs are not determined by direct ratio to total output, but rather by classification of service as to basic, secondary, surplus, excess, etc., which means that the total services rendered by a utility shall yield a revenue sufficient to make the utility self sustaining, but not render a profit, for such is beyond the cost of service.

[1] Presented before the California Section meeting, October 29, 1930.

[2] Assistant Civil Engineer, Department of Water and Power, Los Angeles, California.

THE STANDARD GRADING SCHEDULE

We cannot speak of fire protection without thinking of insurance. The question of insurance leads us at once to the National Board of Fire Underwriters who have adopted a standard schedule for grading the fire protection facilities of a municipality. Lacking authority to require the installation or regulation of any of the various fire fighting facilities, the National Board can only grade or classify according to the probability of a conflagration. These gradings are used by various insurance rating bureaus throughout the United States for the purpose of applying a uniform rate in determining the amount of premium to be paid by the insured.

The people being served by a water works with fire protection are in a position, however, to require a water company to so construct and operate the system as to place at the disposal of the fire department (volunteer or enlisted) the best facilities to protect their property from loss.

While the grading schedule may not be absolutely perfect, it represents a system of weights applied to the different facilities by men who are concerned primarily with losses resulting from fire. This schedule is published as an appendix to the "Water Works Practice Manual" of the Association so I will not attempt to reproduce any part of it here as every member should have a copy in his library.

The schedule operates as a system of demerits, so many points being chalked up for each fault found in the different functions. It is most difficult to determine mathematically which service is more valuable or important, because of the varying probability that a deficiency may be found to exist in any item used in the schedule. It is to our purpose, however, to review the thirty-two items of grading the water supply and consider what is expected of the water works. The thirty-two items may be divided as follows; two items on personnel system, one for reliability of source of supply, twelve for distribution system, eight for pumping plants, five for fire hydrants, and four items of a miscellaneous nature.

The two items for personnel cover the subject of appointment of employees and qualifications of the chief executive. A maximum of 40 points is possible for full deficiency. The one item of reliability of source of supply has a maximum of twice the deficiency scale or 400 points, and consider the elements of duration of drouth, danger of floods, forest fires, absence of watchmen where needed and any other factors that would affect adequacy from source of supply. The

twelve items of distribution system consider in general the ability of the system to keep up a minimum pressure under required fire flow, including the main item, allowing 2½ times the deficiency scale for adequacy of the larger transmission mains supplying larger districts. The pumping plants are graded principally for sufficiency of reserve capacity plus condition and location or arrangement of equipment. The miscellaneous items affect records, emergency repairs, receipt of alarms and electrolysis.

POSITION OF REGULATORY COMMISSIONS

The production and sale of services rendered by public utilities have developed, under prevailing conditions, until they are practically free from competition within the confines of their territories. As a result of such a situation, the government has taken jurisdiction for the purpose primarily of regulating a balance between cost and income. Necessary to maintaining such a balance the board or commission appointed to regulate public utilities must have authority over the service rendered, alienation of property, accounting and other related operations. The balancing of cost with income does not imply that the income must be sufficient to cover all expenses whatever they might be. Thus, judicial rate fixing involves a detailed study of reasonableness of costs and an investigation to determine the efficiency of the organization.

Such jurisdiction is vested in the separate states with the Interstate Commerce Commission regulating business transacted between states. Although certain types or kinds of utilities are exempt from regulation in various states, it is believed that the findings of the California Railroad Commission as regards public fire protection will be of interest. Quoting from our own Railroad Commission,—

"In the case of Berkley V. East Bay Water Company, 23 C.R.C. 868–871, the commission states itself in terms fundamental in matters of jurisprudence as regard liability or responsibility. 'Municipalities should pay a proper proportion of total cost of fire protection utility service and the commission cannot recede from the position heretofore taken because of the fact that one consumer finds it difficult or inconvenient to pay its share of expense.'"

The next three quotations develop a standard of relation between cost and amount of protection afforded, each one being a step improving the preceding.

Corona City Water Co., 6 C.R.C. 16–19. "It is difficult to accu-

rately fix a rate which should be charged for fire hydrant rental by cities as there is only an occasional use of water, while the size of main and water facilities must at all times be kept adequate for fire purposes so as to be ready when the demand comes."

Van Nuys Water System, 16 C.R.C. 125–128. "A charge for fire protection does not necessarily vary with the quantity of water used for this purpose, but rather with the amount of protection afforded."

Manteca Water Works, 19 C.R.C. 400–402. "In a schedule of flat rates for water, a distinction between single and double outlet fire hydrants is not warranted when all hydrants are attached to the same size mains and their delivery capacity is limited by the capacity of the mains rather than the number of outlets."

The development of such policies by the various commissions has resulted in the inch foot method of charging for fire protection. A good example of the connecting link between charge and payment is the case of Eshlemann V. Title Guarantee and Trust Co., 10 C.R.C. 680–683, in which it is stated that "The burden of a fire service rate should be borne in proportion to the benefit obtained, and payment therefore should be closely proportioned to assessed valuation of inflammable property."

By reference to "proportion to the benefit obtained," is meant distribution of the charge among those benefited in proportion to the amount of inflammable property held by them, rather than benefit obtained referring to value of service.

The significance of this last position will further be shown preceding the accompanying recommendation, at the close of this paper.

As to apportionment of costs between domestic water users and fire protection, we have the position of the Wisconsin Railroad Commission in application of Kenosha Municipal Water Plant for authority to increase its rates, 15 W.R.C.R. 426. "Some water works men have held that the only charge which should be paid for fire protection is the actual added cost of the service above what the cost would be for a system to furnish general service only. This seems no more logical than it would be to argue that the rates for general service should be only enough to cover the excess of the operating costs of a combined plant over the operating costs of a plant to furnish adequate fire protection only. The correct principle seems rather to be that the two classes of service furnished by water utilities are coördinate; that as far as possible each should be self-supporting and that when this is not the case, there is to some extent an unfair discrimination either

in favor of the city which uses fire protection or in favor of the general users who use water for culinary and sanitary purposes."

Regarding the question of interest on invested money. The decision in the case of Compton Water and Land Co., 22 C.R.C. 173–174, states, "Where fire hydrants connected with a water system were not the property of the company, rates were established commensurate with the value of the service rendered, but which would not reflect any interest return upon the money invested in the hydrants."

The question of whether or not a utility is entitled to earn interest on donated capital is debatable. On the relation of property and its use to the proprietor, of the inclusion or exclusion of certain items from the valuation, a Special Valuation Committee of the American Society of Civil Engineers stated in its report printed in the Proceedings of 1917, page 1350; "When a valuation of a public service property is made, it is frequently necessary in order to be fair to all parties interested, to depart from the usual rules relating to ordinary private property, and include in the valuation more or less property situated on land to which the owner of the public utility has no title, and on the other hand, to exclude property situated on land to which he has a title.

"The proper general rule, subject to exceptions appears to be that the owner of a public utility is entitled to have included in the valuation of his property all those works for which he has been required by law or necessity to pay the cost, including in this class also, property voluntarily donated, and that there should be excluded all those works for which other public service companies, the public or the users have been required by law or necessity to pay the cost."

COST SCHEDULE

The question now before us is the apportionment of costs. Predicated on the previously mentioned principle that the charge for a service must be commensurate with its cost, those charged with the responsibility of rate schedules, not so long ago, attempted to establish rules for the mathematical distribution of costs to the different classes of consumers. Of course, such rules as originally established were not long consistent with prevailing conditions. Under present business conditions, therefore, it is impossible to establish such definite rules.

The difficulty most commonly encountered is that rates so established are frequently more than the traffic will bear. Which simply means

that for industrial water users, either the whole class or those using the larger quantities find other means of developing the water cheaper or they cannot afford to pay the price and make a profit in competition with business from other locations. On the other side of the picture, we have the utility which by reason of such a tariff, loses business and is thereby unable to show a favorable return. Then comes the problem; should the water works increase the rates in some other class or can it, by reducing the industrial rate, create a sufficiently larger volume of business to offset such reduction and bring the earnings back to balance with the cost?

Reverting again to the rate structure, wherein we allocate the costs to class of service, convert them into "unit costs" and from such units formulated the rate schedule, let us refer to the experience of Los Angeles. Water is brought down and delivered by the aqueduct at an average cost of 4½ to 5 cents per 100 cubic feet F.O.B., San Fernando Reservoir. Yet we know that the irrigationist in San Fernando Valley cannot afford to pay such a price and make money on his crops. Additional study and analysis show that there are advantages to the other consumers to have the water spread for underground storage. The rate originally adopted was 1.2 cents as representing the cost of supervision, and controlling the use of water, thereby making the remaining consumption carry a cost of aqueduct water at about 7 cents per 100 cubic feet. Then as the agriculture conditions of San Fernando Valley improved, the rate was increased to 1.8 cents so that they might more properly share with other consumers the cost of the water department.

Let us apply the same principles of rate making to the problem of fire protection service, forgetting for the time being the element of what the traffic will bear, as this will be discussed in the next section. First, let us review the different operations of a water department and with the requirements of the grading schedule and principles so far developed in mind discuss the allocation of charges, considering the two services coördinate. It would be to no purpose to use either percentages or actual figures for any one city as conditions in another city would be radically different, as shown by Metcalf, Kuichling and Hawley. In the classification below, the operations are grouped according to the different functions, it being assumed that from the accounts the costs are allocated to these items, and should include the operating expenses, depreciation, taxes, and, when applicable, interest

on investment. General expenses for buildings and equipment should be allocated to the function served. The classification is as follows:

1. *Source of Supply*
   - (a) Collecting
     - (1) Underground facilities
     - (2) Surface facilities
   - (b) Impounding
   - (c) Transmission
   - (d) Pumping
   - (e) Purification—(filtration and wholesale treatment)
2. *Distribution*
   - (a) Street Mains
   - (b) Reservoirs and Tanks
   - (c) Fire Hydrants
   - (d) Services
   - (e) Meters
   - (f) Pumping (boosting for reservoirs and tanks)
   - (g) Purification (chlorination from reservoirs)
3. *General*
   - (a) Administration and Supervision
   - (b) Legal Expense
   - (c) Injuries and Damages
   - (d) Insurance and franchises not allocated
   - (e) Accounting
4. *Commercial*
   - (a) Meter Reading
   - (b) Billing
   - (c) Collecting
   - (d) New Business

It should be noted that pumping and purification costs are split as to source of supply and distribution, the reason being that consideration given their costs would vary with their function, and nature of the system.

While discussing the apportionment of costs you will note that no detail is presented, chiefly because of the great variations that exist among the water works and because the majority of other papers presented on this subject have presented their side of one or more methods and view points. The most detailed paper, and to which I have previously referred, that of Metcalf, Kuichling and Hawley (1911, Proc. A. W. W. A.) presents a great many fundamentals, all of which, as well as others which have since been developed, should be considered.

In analyzing the source of supply facilities, two factors should be

considered; first, is it a direct supply; second, is the supply regulated through reservoirs of an impounding and distribution nature. In some systems very little physical relation will be found between source of supply and fire protection. In connection with such systems, may I direct attention to the review of the National Board of Fire Underwriters, where they take into consideration the adequacy of source of supply. Is it necessary for such utility to spend a great amount of money perfecting and acquiring water rights or developing a source for the purpose of keeping such supply adequate with the growth of the community? If so, it is only proper that fire protection should receive some of the source of supply cost.

The distribution costs are probably where the most charges will be found affecting fire protection. Fire hydrant costs are charged to the extent of 100%; but of the remaining items, street mains and reservoirs probably represent charges for property serving both consumers jointly. The exact method of apportionment may be open to argument. If capacity alone were the criterion, the answer would be one thing, but if full allowance is made for the fact that the pressure required under constant flow for fire protection is a demand which also makes facilities adequate for general consumption, it is, therefore, under such hypothesis, chargeable to both services. Meters and services belong to the water users alone. Pumping and purification are subject to more varying conditions.

Of the general expenses, some are no doubt attributable to supervision and overhead of the function serving for fire protection. Consideration should also be given to the problems affecting design of system to provide adequate protection, which reflect in a professional way on the efficiency and qualifications required of the executive personnel. The logic here is that where skilled or professional services are required in connection with a problem having two fundamental functions, the one having the more difficult problems influences the selection from among the list of those available and thereby also influences the cost of such services.

The last item of commercial costs presents little or no relationship to fire protection.

Using the principles outlined, an allocation of the costs for the City of Los Angeles covering the past three years' operations gives the results shown in table 1.

A tabulation of cities whose water works have been reviewed by the Wisconsin Railroad Commission was prepared in 1919 by J. N.

TABLE 1

Allocation of water supply costs in Los Angeles

	1926-27	1927-28	1928-29
Distribution system costs chargeable to fire protection	$684,958	$807,148	$779,243
Standby for water production, required fire flow at 6¢ per 100 cu. ft.	343,200	380,060	386,438
Total Cost, exclusive of fire hydrants	$1,028,158	$1,187,208	$1,165,681
Maintenance and depreciation of fire hydrants	31,153	32,648	41,373
Total Costs applicable to Fire Protection	$1,059,311	$1,219,856	$1,207,054
Inch feet of mains in system	128,786,000	134,549,000	145,418,000
Average number of hydrants per year	12,422	13,695	16,159
Cost per inch foot	$\frac{1,028}{128,786} = 0.0080$	$\frac{1,187}{134,549} = 0.0088$	$\frac{1,166}{145,418} = 0.0081$
Maintenance and depreciation per hydrant	$\frac{31,153}{12,422} = 2.508$	$\frac{32,648}{13,695} = 2.384$	$\frac{41,373}{16,159} = 2.56$
Justifiable annual charge			
0.0082 per inch foot of main	$1,056,045	$1,103,302	$1,192,428
Plus 2.50 per fire hydrant	31,055	34,237	40,398
	$1,087,100	$1,137,539	$1,232,826

In the above allocation of costs, pumping, purification, and bond carrying charges were only allocated through the standby charge and have the effect of apportioning about 9 percent of the cost to fire protection. Throughout the costs no interest on the investment of plant was considered, other than bond carrying charges as an independent item, because of conditions peculiar to Los Angeles and its rate structure.

Chester, wherein he shows from 25.3 to 52 percent of the gross earnings from fire protection. Similar decisions from the Pennsylvania Commission show a range of 16 to 20 percent from fire protection. A similar comparison of Los Angeles would show an average of about 12 percent of gross earnings from fire.

TABLE 2

Public service costs in Los Angeles

	1926–27	1927–28	1928–29
Estimated Population	1,080,000	1,130,000	1,190,000
Assessed Valuation	$1,575,789,715	$1,728,188,625	$1,863,747,170
Cost of Police Department	$6,335,065.63	$6,532,464.34	$6,713,923.00
Ratio to assessed valuation, per cent	0.402	0.379	0.360
Cost per capita, dollars	5.87	5.78	5.64
General Street Lighting, excl. of special districts	$907,803.38	$971,989.08	$1,007,759.06
Ratio to assessed valuation, per cent	0.057	0.056	0.054
Cost per capita, dollars	0.84	0.86	0.85
Cost of Fire Department	$4,098,783.90	$4,538,712.43	$4,688,036.16
Ratio to assessed valuation, per cent	0.26	0.26	0.25
Cost per capita, dollars	3.79	4.02	3.94
Justifiable charge for fire protection from Water Works	$1,087,100	$1,137,539	$1,232,826
Ratio to assessed valuation, per cent	0.069	0.066	0.066
Cost per capita, dollars	1.01	1.01	1.04

Granting that the best test of whether such a charge is more or less than the traffic will bear, is the reaction received when it is actually put into effect, we can make certain determinations by comparing with the cost of other public service.

There is, however, no substitute for an adequate water supply for subduing a larger conflagration. Present methods of fire fighting adopt a sparing and skilled use of chemicals for smaller fire, where water in larger quantities would do unnecessary damage. It is very

doubtful that the public and those charged with responsibility for controlling fires would relinquish their demand that the water departments provide a water supply adequate for fire protection.

It is therefore, not a problem of creating more expense to the people, but of placing the costs where they belong.

A comparison of the costs of the principal public services for Los Angeles is shown in table 2.

Where the people spend nearly $6 per capita for the Police Department and $4 for the Fire Department there should be no objection to paying $1 for rendering available an adequate water supply. As against those that pay the bill as well as receive the benefit, it would mean a direct tax of less than 7 cents per 100 dollars of assessed value.

TABLE 3

Fire insurance in State of California

YEAR	ASSESSED VALUATION OF STATE	NET AMOUNT WRITTEN	NET PREMIUM RECEIVED	RATIO OF PREMIUM TO AMOUNT WRITTEN	RATIO TO ASSESSED VALUE	
					Of amount written	Of premium
	dollars	*dollars*	*dollars*	*per cent*	*per cent*	*per cent*
1924	9,700,664,565	3,759,428,489	42,235,878	1.12	38.75	0.44
1925	10,783,460,562	3,987,452,841	44,096,769	1.11	36.98	0.41
1926	11,244,462,059	4,237,362,648	47,018,367	1.11	37.68	0.42
1927	11,862,454,249	4,324,822,861	45,459,855	1.05	36.46	0.38
1928	12,439,653,999	4,245,316,295	45,670,817	1.08	34.12	0.37

But the above items do not include all that is paid for the protection of property.

REVIEW OF INSURANCE CONDITIONS

Frequently the question is asked in connection with fire protection charges; what is the value of the service and will the cost of the service be offset by an equal reduction in insurance rates? It is a natural tendency to associate savings in insurance premiums with cost of fire protection. But they are two distinct functions, one pays for the loss by reimbursement to the insured, the other, pays for a service required for limiting the loss.

It is an extremely difficult thing to determine the amount of insurance at risk as well as the amount of annual premium thereon for any given area so that comparisons can be made between the amount

at risk and the total assessed valuations. In the annual reports of the State Insurance Commission for California a tabulation is given of the amount of insurance written in the state and of the premiums received for the year. As the amount written includes two to five year term policies, it does not correctly represent the amount at risk, but the facts in table 3 may permit us to form an opinion.

The report of the National Board of Fire Underwriters for the year 1928 quotes for the total business of 192 United States Companies an average ratio of 0.8944 percent premiums to amount covered. There would be properly also the uninsured losses and the amount spent for fire protection facilities within the premises of the individual.

REVIEW OF THE PROBLEM

While there has been a great deal written and said on the apportionment of charges by such emminent members of this Association as L. Metcalf, J. W. Alvord, J. N. Chester, W. C. Hawley, R. L. Dobbin, and J. C. Keith, I believe we have been discussing a question upon which we all have agreed, perhaps not in detail as to exact method of apportionment, but in substance that each system should be treated as a unit and each problem analyzed separately.

Such articles and the fundamentals which they bring out are essentially the second step for consideration of the men selected to make a study of the costs in connection with a works.

Some who have studied the problem of costs state that the apportionment of the total costs as a rule is heavier for smaller than for larger cities. As we are always guided by the policies adopted in the larger cities, I have prepared a tabulation of the 93 cities whose population is over 100,000, with data taken from recent publications. A postal card was sent to each on the list notifying them of my intention of using said information in this paper. If no reply was received it was assumed as correct. To those for which no information could be found, a letter was written requesting it, some 20 in all. Of those Birmingham, Alabama and Camden, N. J., were the only ones from whom no answer was received. The cities are arranged in order of size according to 1930 census.

A brief glance at table 4 shows that progress has been slow, and in some cases backward.

Some of the cities replied that the charge was not made in lieu of consideration from the city government exempting them from taxes. I do not believe I need to say much to this group regarding this prac-

TABLE 4

Cities with over 100,000 population and their fire protection charges

NUMBER	CITY	OWNERSHIP	ANNUAL HYDRANT RENTAL
1	New York, N. Y.	M	None
2	Chicago, Ill.	M	None
3	Philadelphia, Pa.	M	None
4	Detroit, Mich.	M	None
5	Los Angeles, Calif.	M	$36.00 Not collected in cash
6	Cleveland, Ohio	M	None
7	St. Louis, Mo.	M	None
8	Baltimore, Md.	M	$24.00
9	Boston, Mass.	M	None
10	Pittsburg, Pa.	P	$32.50
11	San Francisco, Calif.	M	$36.00
12	Buffalo, N. Y.	M	$15.00
13	Milwaukee, Wis.	M	$10.00
14	Washington, D. C.	M	None
15	Minneapolis, Minn.	M	$5.00 Increase is under consideration
16	New Orleans, La.	M	None
17	Cincinnati, Ohio	M	None
18	Newark, N. J.	M	$25.00+ (American City, Oct. 1929)
19	Kansas City, Mo.	M	None
20	Indianapolis, Ind.	P	$12.00+ 1¼ cents per inch foot
21	Seattle, Wash.	M	$9.00
22	Atlanta, Ga.	M	None
23	Rochester, N. Y.	M	None. Private Company adjoining gets $113.00 per hydrant
24	Jersey City, N. J.	M	None
25	Louisville, Ky.	M	None
26	Portland, Ore.	M	None
27	Toledo, Ohio	M	None. Matter under discussion
28	Houston, Tex.	M	None
29	Columbus, Ohio	M	None
30	Denver, Colo.	M	$22.50
31	Oakland, Calif.	P	$4.40 Average
32	St. Paul, Minn.	M	$14.00
33	Dallas, Tex.	M	None
34	Birmingham, Ala.	P	No reply
35	Akron, Ohio	M	None

TABLE 4—*Continued*

NUMBER	CITY	OWNERSHIP	ANNUAL HYDRANT RENTAL
36	San Antonio, Tex.	M	$30.00 Charges made but not collected
37	Memphis, Tenn.	M	None
38	Providence, R. I.	M	$50.00
39	Omaha, Neb.	M	$60.00
40	Syracuse, N. Y.	M	None. Private Company adjoining gets $60.00 per hydrant
41	Dayton, Ohio	M	None
42	Worcester, Mass.	M	None
43	Richmond, Va.	M	None
44	Oklahoma City, Okla.	M	None
45	Youngstown, Ohio	M	None
46	Grand Rapids, Mich.	M	$35.00
47	Hartford, Conn.	M	$5.00
48	New Haven, Conn.	P	None
49	Fort Worth, Tex.	M	None
50	Flint, Mich.	M	None
51	Nashville, Tenn.	M	None. Outside City $40.00
52	Springfield, Mass.	M	None
53	San Diego, Calif.	M	None
54	Bridgeport, Conn.	P	$0.0142 per inch foot of mains
55	Scranton, Pa.	P	$50.00
56	Des Moines, Ia.	M	$35.00
57	Long Beach, Calif.	M	None
58	Tulsa, Okla.	M	$59.00
59	Salt Lake City, Utah	M	None
60	Paterson, N. J.	P	$10.00 + $0.0084 per inch foot per annum
61	Yonkers, N. Y.	M	5 cents a front foot of all property fronting mains
62	Jacksonville, Fla.	M	$30.00
63	Norfolk, Va.	M	None. County charge $100.00 per annum
64	Albany, N. Y.	M	None
65	Trenton, N. J.	M	$10.00
66	Kansas City, Kan.	M	$35.00
67	Chattanooga, Tenn.	P	$20.00 per annum + 2 cents per inch foot for additions since 1921

TABLE 4—*Concluded*

NUMBER	CITY	OWNERSHIP	ANNUAL HYDRANT RENTAL
68	Camden, N. J.	M	?
69	Erie, Pa.	M	None. Outside City $50.00 per hydrant
70	Spokane, Wash.	M	$10.00
71	Fort Wayne, Ind.	M	$30.00
72	Elizabeth, N. J.		$.014 per inch foot of mains
73	Fall River, Mass.	M	None
74	Cambridge, Mass.	M	None
75	New Bedford, Mass.	M	None
76	Reading, Pa.	M	None
77	Miami, Fla.	P	None
78	Wichita, Kan.	P	$37.50
79	Tacoma, Wash.	M	$40.79
80	Knoxville, Tenn.	M	$45.00
81	Canton, Ohio	M	None
82	Wilmington, Del.	M	None
83	Peoria, Ill.	P	$32.41
84	South Bend, Ind.	M	$40.00
85	Somerville, Mass.	M	None
86	Evansville, Ind.	M	$14.50
87	Utica, N. Y.	P	$40.00
88	Lynn, Mass.	M	None
89	El Paso, Tex.	M	$42.00
90	Duluth, Minn.	M	$50.00
91	Waterbury, Conn.	M	$10.00
92	Tampa, Fla.	M	$20.00
93	Lowell, Mass.	M	$12.00 Charges made but not collected

M = municipally owned; P = private company.

tice. Charges for fire protection and taxation are two separate and distinct arguments and only confuse the issue when they are handled collectively.

The state of Ohio, by statute, requires municipally owned water works to render free fire protection service to the municipality.

Nebraska and Kansas, however, have a statute for the collection of a tax within municipalities from which the charge of the waterworks

for fire protection can be paid. They are evidently optional laws, for we find a number of cities within those states paying no such charges.

The problem then is one of public policy rather than one requiring technical investigation.

RECOMMENDATIONS

As a result of the consideration and study given to the problem, I have come to the conclusion that two things should be done. First, a complete survey and study should be made of the various and specific conditions as they pertain to cities of the west coast, particularly California; second, to insure payment of a proper allocation of the costs by the sources of property to which they are applicable, a tax should be levied creating a fund against which bills would be rendered.

In order to accomplish these objectives and in consideration of circumstances surrounding such tasks, the following recommendations are submitted. Each water works in California, those represented in the membership of this section, and such others as can be prevailed upon, should prepare a study of its system showing the allocation of cost to fire protection, as well as the total sum to be earned, detailed as to the costs of the business, as operating expenses, depreciation, etc. These studies should be submitted to a committee, of this section, for review, recompilation and publishing in The Journal at an early date. If practicable, these reports should be handled in conjunction with a questionnaire which I understand is in progress of preparation.

The desirable method of applying the tax would be against inflammable property. However, that would involve a great deal of additional work for the assessors. The next feasible method would be against improvements to real estate. But if applied against all property, it would compel another class of non-water-using consumer to contribute toward the support of the water works installed for his benefit and maintained until he does become a water user. I refer to the vacant lot owner. This would not be inequitable, as such allocation of costs is for that part of a system necessary for a readiness to serve as reflected in the distributing system and as an adequate available supply. Therefore, in applying the tax there is no vital necessity to deviate from the present method of levying. If we attempt to approach county supervisors or city government, the result will be victory here and there, as now, with less possibility of

standardizing of practice. A state statute would allow a concentration of efforts and bring about uniform practice for neighboring communities.

It is, therefore, recommended that a resolution be adopted by this section directed to the National Organization requesting that a committee be appointed to develop a plan of contacting the various state legislatures for the purpose of formulating a law providing that a tax be levied in each district served by a water works, either municipal or private, including county districts. The income, from such taxation should be deposited to the credit of the district out of which the controller or other designated party can pay bills for fire protection rendered by the Water Works, at rates determined by a disinterested competent authority and adopted by those vested with the authority of making the rate schedule effective.

In California, the State Railroad Commission may be designated as the disinterested competent authority.

Note: The author wishes to acknowledge the assistance of C. M. Street, Junior Civil Engineer of Department of Water and Power.

WATERWORKS INTAKES AND THE SCREENING OF WATER[1]

By John W. Cunningham[2]

The subject of waterworks intakes is a very broad one, and this paper will cover only a limited field, the diversion of water from flowing streams. The application is particularly to the situation in the Pacific Northwest. This section is naturally favored in its surface water supplies, and a large majority of its waterworks systems have gravity lines diverting from streams.

Surface water from a single source will vary greatly in its physical characteristics. In the winter, it may carry slush ice, or be so close to the freezing temperature that the subtraction of a little more heat along the pipe line causes freezing. Freshets, originating in rain or melting snow, usually bring silt and sediment, with resulting high turbities. Floods at the same time usually bring down an accumulation of logs, brush, roots, pine-needles and miscellaneous débris from the stream banks. The summer water conditions are in most cases the best of the year, but on some streams there are periodical runs of algae which are very troublesome. The fall season brings down the leaves of deciduous trees, often in such volume that racks and screens are blocked, and continual attention and raking is found necessary. The accumulation of such leaves is the main cause of vegetable stain, or discoloration. During a large portion of the annual cycle the waterworks superintendent has his intake troubles and any possibility of excluding the débris and reducing the turbidity will be of interest.

Stain, or turbidity originating in colloidal clays can only be removed by special treatment, but most surface waters can be greatly improved by the simple processes of screening and sedimentation. It must be remembered that suspended solids in water only remain suspended by virtue of currents and agitation. If given an opportunity, the difference in specific gravity will take them either to the

[1] Presented before the Pacific Northwest Section meeting, April 25, 1930.

[2] Consulting Engineer, Portland, Oregon.

top or bottom. Some material, notably leaves and wood, at first tends to float, but ultimately becomes water-logged and settles to the bottom.

INTAKE DESIGN

The first opportunity for improving the quality of water is in the design and arrangement of the intake itself. It requires no explanation that swift, turbulent water carries more sediment and débris than quiet water. The first aim should be at least a moderate storage and sedimentation space above the intake. While the intake must conform to local and special conditions, some form of dam is quite essential to check the water, induce settling, and give head for operating sluiceways and screens. In connection with a dam, or in the absence of a dam, the intake proper should be placed in the deepest available water. If the stream curves, it is an advantage to be on the concave side of the curve, since the thread of the current with both sediment and floating débris swings to the outside or convex side. Water should, if possible, be diverted in a manner which will exclude floating material. The best way to accomplish this is with some form of boom. Even a very modest structure can usually be provided with the equivalent of a boom, or a surface baffle board.

To minimize the heavier solids entering the intake the floor or sill should, if possible, be placed above the bed of the stream. The heavier gravel and sand which cannot be picked up by the current or carried in suspension rolls along the bottom and will not enter a higher inlet. If there is no dam, it will pass on down stream. With a dam, it will accumulate and bank up. To get rid of this, and prevent building up to the intake floor, sluice gates should be provided and frequently opened.

For the first line of defence at the intake we have the coarse racks, designed to keep out floating branches and sticks. It is hard to understand why most waterworks intake racks are so poorly considered. In power work it is standard practice to build inclined racks, which can be raked from a convenient platform. For water supply, we often find racks which can be reached and cleaned only from a boat or by an acrobat. We see them with cross members which catch the teeth of the rake and entangle débris. We even find coarse mesh or gratings which defeat convenient cleaning. A general rule may be stated that, while size and spacing of rack bars should fit the case in hand, all racks should be placed on a slope of 2 inches to 4

inches, in 12, with a working platform at the top. We used to string rack bars on rods with pipe spools or spacers, but the advent of welding makes it possible to support the bars from the back and leave a deep space to clear the teeth of the rake used.

INTAKE SCREENS

After the water has passed the racks, the next feature is the intake screen. The purpose is to remove and keep out of the supply line or the system the twigs, leaves, grass, roots, moss and other suspended débris. The larger waterworks intakes usually have fairly efficient screen arrangements, where men are continually on duty at the intake. The question of screen maintenance is not serious, although it may be exacting during flood and leaf seasons. The real problem comes at the small waterworks intakes. In the Pacific Northwest we have many gravity water supplies ranging from 250,000 to 5,000,000 gallons with pipe lines 10 to 15 miles long. Obviously, such plants cannot afford to keep a regular man at the intake, and their screen layouts are usually the crudest and least effective. Trouble at the intake is commonly indicated by a falling off of the supply, and the superintendent must drive or walk up to the intake to clean the screens. In leaf seasons the cure is but temporary and the maintaining of the screens is a continual nuisance and expense.

For the largest waterworks plants, such as the one on Bull Run River, there have been developed continuous screens of the Rex type which are efficient and require little manual attention. They are, however, made in large units only, expensive, and require power and water under pressure for their operation. For small supplies, where the trouble is most serious they are not adaptable. There is a very definite need and demand for a screen arrangement or device which is at least partly automatic in action and self-cleaning; something which will operate for a day or several days in leaf season without attention. Reference will be made to some drawings or figures which are better than description to bring out schemes for accomplishing these results.

Figure 1 is an intake arrangement adaptable to quite small supplies, a million gallons or less. It is based on the principle that suspended material tends either to sink or float. It uses a relatively large area of screen, giving low velocities. It is also uses a screen made up of vertical wires or bars only. The reason for this was the observation that the horizontal wires of a mesh catch leaves or roots and hold

them against floating or sinking. A leaf drifting against the vertical wire screen will usually slip up or down, more often down, clearing

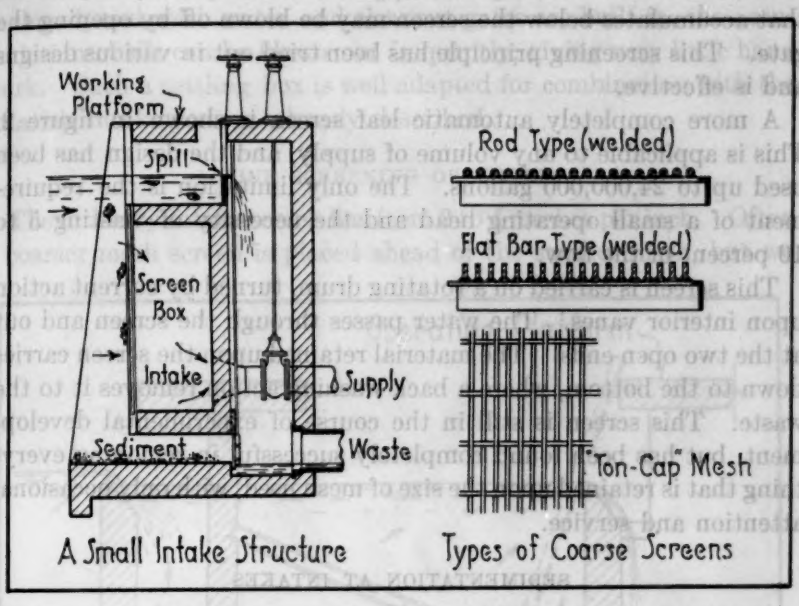


FIG. 1

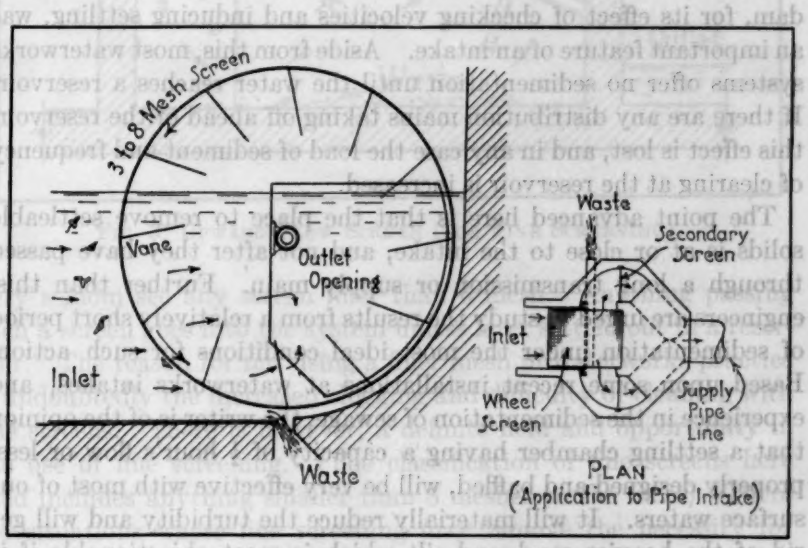


FIG. 2. SELF-CLEANING LEAF SCREEN

the screen area. If it comes to the top, it floats into the space provided, and if water is being wasted, goes over the spillway. Material that accumulates below the screen may be blown off by opening the gate. This screening principle has been tried out in various designs and is effective.

A more completely automatic leaf screen is shown in figure 2. This is applicable to any volume of supply, and the design has been used up to 24,000,000 gallons. The only limitation is the requirement of a small operating head and the necessity of wasting 5 to 10 percent of the flow.

This screen is carried on a rotating drum, turned by current action upon interior vanes. The water passes through the screen and out at the two open ends. The material retained upon the screen carries down to the bottom, where a back washing action removes it to the waste. This screen is still in the course of experimental development, but has been found completely successful in removing everything that is retained upon the size of mesh used, with only occasional attention and service.

SEDIMENTATION AT INTAKES

The discussion of intakes and intake screens brings up a related matter, that of sedimentation. It has already been stated that a dam, for its effect of checking velocities and inducing settling, was an important feature of an intake. Aside from this, most waterworks systems offer no sedimentation until the water reaches a reservoir. If there are any distribution mains taking off ahead of the reservoir, this effect is lost, and in any case the load of sediment and frequency of clearing at the reservoir is increased.

The point advanced here is that the place to remove settleable solids is at or close to the intake, and not after they have passed through a long transmission or supply main. Further than this, engineers are urged to study the results from a relatively short period of sedimentation under the most ideal conditions for such action. Based upon some recent installations at waterworks intakes, and experience in the sedimentation of sewage, the writer is of the opinion that a settling chamber having a capacity of ½ hour's flow or less, properly designed and baffled, will be very effective with most of our surface waters. It will materially reduce the turbidity and will get rid of the heavier sand and silt which is most objectionable if it gets into the line.

A small settling box, as suggested, will usually fit into the remainder of the intake design and will be relatively inexpensive. If the bottom is sloped, and wash water and cleanout gates are built in, the accumulation of silt can be blown out frequently, giving very little hand work. Such a settling box is well adapted for combination with the rotating intake screens already described.

FINE SCREENING OF WATER

The ordinary intake screen has from 2 to 4 meshes per inch. Often a coarser mesh screen is placed ahead of the smaller mesh, but we

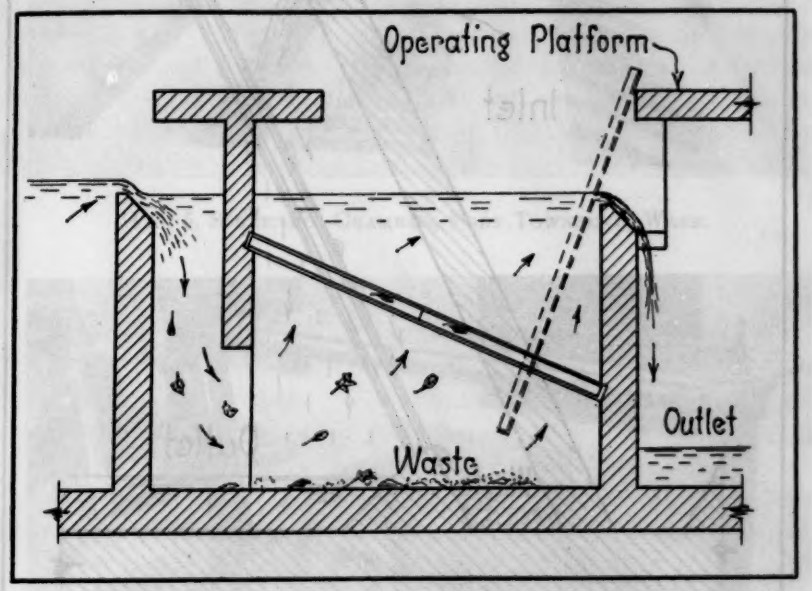


FIG. 3. UPWARD FLOW SCREEN (FOR FINE SCREENING)

very seldom see any screen finer than 6 mesh. Anything passing such a screen goes into the system unless later settled out in a reservoir. The reason for not using a finer mesh in waterworks practice is undoubtedly the increased clogging and difficulty of cleaning with fine screens. There is however, a definite field and opportunity in the use of fine screening. (The classification of fine screens here used includes anything smaller than 8 meshes to the inch.) There are situations where fine screening may remove the necessity for filtration. For example, in the manufacture of certain grades of

pulp and paper the main objection is to material which causes clogging in showers and washers, which is not taken out by ordinary mesh, but may be removed by fine screens. This material includes fine hair-like roots, pine needles, moss and certain forms of algae.

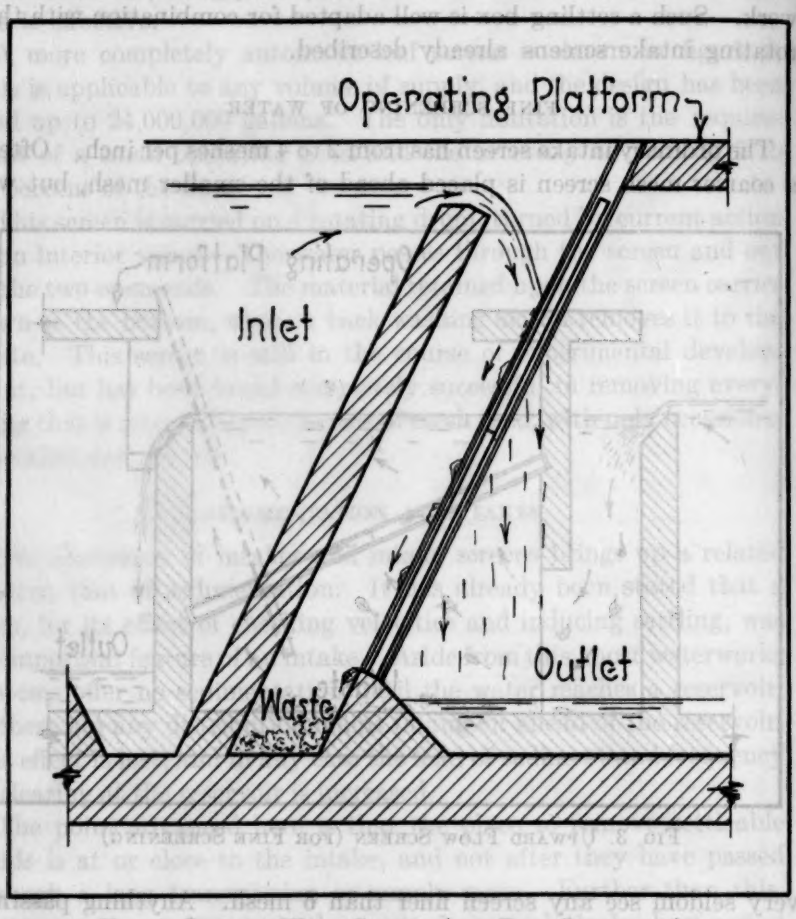


FIG. 4. SURFACE WASH SCREEN (FOR FINE SCREENING)

The limit of fineness to which screening is practicable is a question. It depends upon character of the water, screen design, and the cost that the undertaking will stand. In general, the finer the screen, the lower the velocities and the larger the screen area which must be provided. One requirement to be met in the design of fine screens is easy maintenance. Such screens, if effective, must be kept clean

and they should be made either self-cleaning or quickly and inexpensively cleaned. Figures 3 and 4 show arrangements for fine screens. Figure 3 is an upward flow screen which has been applied

FIG. 5. SCREENING CHAMBER, PORT TOWNSEND, WASH.

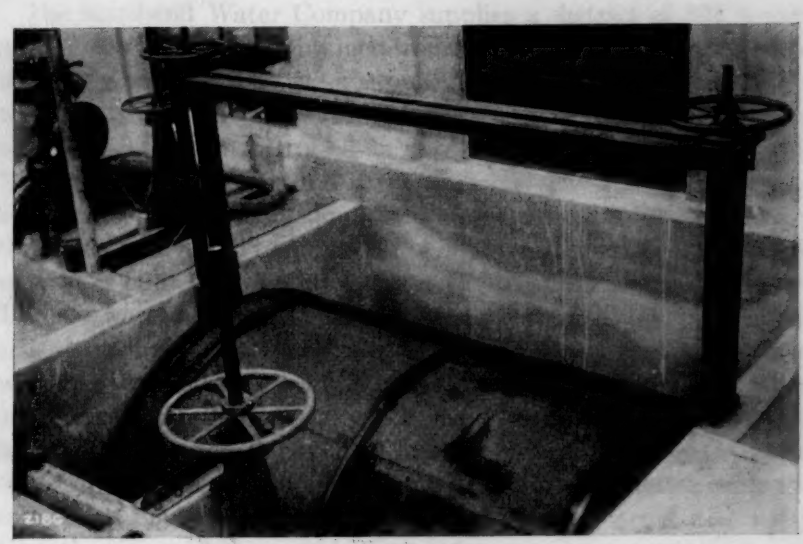


FIG. 6. SELF-CLEANING SCREEN

in two screening plants, and figure 4 is a sloping screen, which works on much the same principle as the ordinary mason's sand screen.

A necessity for fine screens is to secure a low velocity and a uniform

distribution of flow over the entire area. Short circuits and dead spots make the screen less effective and less economical. The upward flow screen of figure 3 uses weirs to distribute the water. The object of the upward flow is to permit washing down the screen by the use of a hose stream. If brushing is necessary, the screen sections may be tilted up as shown. Gates provide for control, washing and waste operations.

The aim of this paper is to emphasize the fact that a waterworks intake and screening plant are of an importance which deserves much more thorough study and careful design than they usually receive. The man who operates the plant usually realizes this more fully than the engineer who designed it. The engineer, however, is in a better position to apply the various hydraulic and mechanical principles which go into the design if he will only do so.

OBSERVATIONS OF WATER SUPPLIES OF LONDON AND PARIS[1]

By Edward Bartow[2]

Through the courtesy of Mr. William Paterson of the Paterson Engineering Company, I was invited to accompany Sir Alexander Houston and Dr. Beale of the firm of Thresh, Beale, and Suckling to the water purification plant of the Southend Waterworks Company at Langford. We were met at the plant by Mr. E. C. Bilham, chief engineer, who in connection with Messrs. T. and C. Hawksley, had been responsible for the design and supervision of the construction of this plant.[3]

THE SOUTHEND WATER COMPANY

The Southend Water Company supplies a district of 324 square miles. Water was first obtained from wells until no less than 34 had been constructed. The water supplied from wells became insufficient and it was decided to obtain water from streams, and the present plant which was inaugurated in September, 1929, was the result. The rivers Chelmer, Ter and Blackwater run through sparsely populated agricultural districts and the sewage from towns situated above the intake is diverted to points below. The water passes into storage reservoirs built in two sections, each of 30 million gallons capacity. The raw water after sedimentation for eight to nine days in the storage reservoirs is treated by the excess lime process of purification, which softens and practically sterilizes the raw water. This method of purification follows the suggestions of Sir Alexander Houston in his Tenth Research Report and was adopted after a long series of tests conducted by Drs. Thresh and Beale, in conjunction with the company's engineer, at an experimental plant treating raw water from the rivers Chelmer and Blackwater.

[1] Presented before the Missouri Valley Section meeting, November 7, 1930.

[2] Head of Chemistry and Chemical Engineering, University of Iowa, Iowa City, Ia.

[3] Inauguration of the River Works at Langford, September 18, 1929 by Brig. Gen. R. B. Colvin.

EXCESS LIME PROCESS OF TREATMENT

In the excess lime process the raw water, which is practically free from turbidity, is received at the treatment plant and measured in passing over a weir, which divides it into two variable portions in the approximate ratio of 1 to 6. The smaller portion is mixed with lime to produce sufficient lime water to give an excess of two grains of lime per gallon when mixed with the larger portion. The lime water is prepared by adding cream of lime in mixing tanks where it is

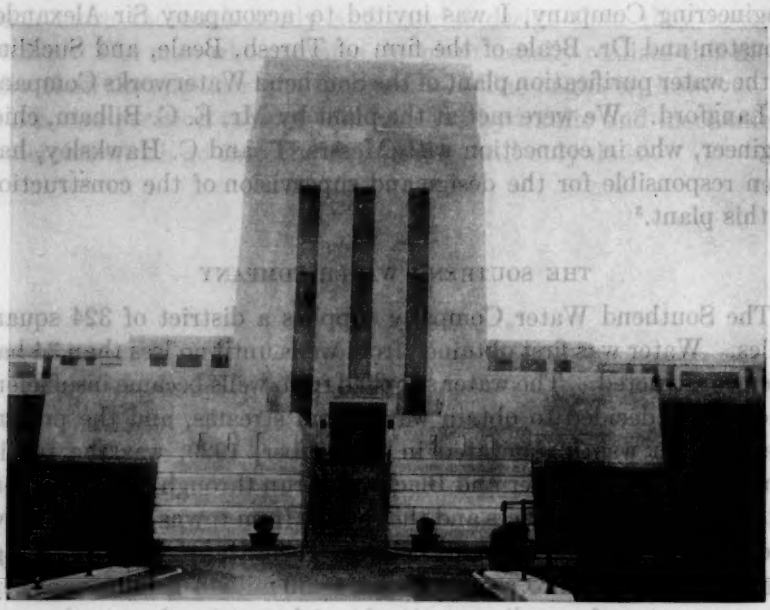


FIG. 1. FILTER HOUSE, KEMPTON PARK, METROPOLITAN WATER BOARD, LONDON, ENGLAND

continuously agitated, and it is then passed forward into a second set of tanks, where it is mixed with the bulk of the supply which has already been treated with alumina. The water is agitated in these tanks for twenty minutes, the result being the formation of a very heavy precipitate which settles out rapidly in the primary settling tanks into which the water then flows, the supernatant water overflowing into a collecting channel. This partially clarified water enters three sets of contact tanks of long rectangular shape, each having a capacity of two million gallons.

Leaving the contact tanks the water passes through the carbonat-

ing chamber where carbonic acid gas is forced through the water precipitating the excess lime and partially redissolving it. Final purification is effected by filtration through a battery of Paterson rapid quartz sand filters, 14 in number, each measuring 24 feet by 14 feet. These filters are cleansed by agitation with compressed air, followed by a reverse flow of wash water to remove the collected matter loosened by the air scouring process.

The used wash water which has been softened and is not loaded with bacteria is collected in a reservoir, and after allowing 12 hours for sedimentation is returned to the mixing tanks, where it mixes with the water undergoing treatment.

Both chemical and bacteriological examinations are made in the laboratory. No coli have been found in 100 cc. samples. The total solids are reduced from 550 to 235 p.p.m.; the permanent hardness from 9.4 to 9.0, the temporary hardness from 23.6 to 1, the total hardness from 33 to 10.

LIME RECOVERY PLANT

Interesting features connected with the process other than those above mentioned are the lime recovery plant. Lime from the primary settlers is transferred to the lime house where it is filtered on a cylindrical filter and sent through a dryer into a rotary kiln. Here the heat is sufficient to drive off the carbon dioxide and make lime. From the nature of the reaction, twice as much lime is made as is needed or used in the process. One-half is returned to the filter plant, the remainder is sold either as quick lime or is hydrated and sold as hydrated lime. Evidently only sufficient lime has been added to precipitate the calcium for it is claimed that the lime prepared is a pure calcium lime and very suitable for further use in water purification.

The water having passed through the large sedimentation basin is practically free from sediment so that there should be no clay in the precipitate from which the lime is made.

REMOVAL OF TASTES AND ODORS BY ACTIVATED CARBON

Another interesting experiment being performed at the plant was the removal of tastes and odors by activated carbon. Carbon having a fineness equivalent to passing through a 300 mesh sieve was added prior to the filters and removed with the wash water. This experiment had been under way for only a few days and, while appar-

ently the tastes and odors were removed, no definite opinions could be obtained as to its efficiency. The odors and taste are in evidence only during one month each year and, therefore, it was felt that the activated carbon could be added in amounts of approximately 10 grains per gallon and thrown away with the sludge from the wash water.

KEMPTON PARK PLANT, LONDON

Through the courtesy of Sir Alexander Houston of the Metropolitan Water Board and Mr. Wm. Paterson of the Paterson Engineering Company, I had the privilege of visiting the Kempton Park pumping station of the Metropolitan Water Board. The new pumping station is described in "Engineering" for October 4 and 11, 1929. The unique features of this plant are a compression tank in which compressed air to be used in connection with washing filters was made by water pressure from the water tanks located 24 feet higher than the compression tanks. The claim is made that economy of construction of the plant is accomplished by this arrangement. The slow sand filters have been in operation for many years. They have recently added the primary or rapid sand filters which have greatly increased the capacity of the slow sand filters. The English have been rather slow to adopt the rapid filters and even now they are used only as primary filters before the slow sand filters. The purified water is sterilized by means of chlorine and ammonium sulfate. This is an illustration of the care used by the Metropolitan Water Board in the purification of the water supply for greater London.

WATER PLANTS AT IVRY AND ST. MAUR

It was through the courtesy of M. Dienert that I visited the water purification plants at Ivry and St. Maur. M. Dienert accompanied me on these visits. He is at the head of the water control laboratory in charge of the purity of water for the city of Paris. At St. Maur, before the war, was located the largest ozone water purification plant in the world. There were two kinds of ozone generators manufactured respectively by Siemens and by the Thompson Houston Company. During the war it became too expensive to furnish the fuel necessary to give current for the ozonizers, and the process of ozonization was discontinued and bleaching powder was used in sterilizing the water at this plant. The ozonizers are still intact and I was told that they might be tried again.

At the plant at Ivry liquid chlorine and javel water, sodium hypochlorite, were both being used. The use of sodium hypochlorite prior to the pump is advocated by M. Bunau Varilla. He has named the process Verdunization because it was recommended by him for use at Verdun. As far as I could determine it makes no difference whether liquid chlorine or javel water is used. In either case the same amount of chlorine was required under the same conditions for the sterilization of the water supply.

At the plant at Ivry it has been customary to wash the pre-filters with a hose to which an iron pipe with perforations was attached and which was placed by hand below the surface of the sand in the various filter beds. Several of the pre-filters are being rebuilt with perforated concrete pipes in the bottom for backwashing of the filters. They will still be used only as pre-filters in connection with the slow sand filters in this plant.

At St. Maur experiments are being made with mechanical filters furnished by at least eight different manufacturers of filtering equipment. This is with the idea of adopting the rapid mechanical filters on a large scale for the city of Paris. German, English and French firms are competing and I was informed that it would be a year or more before they could determine which should be adopted.

It is my understanding that all of the water which is furnished for the city of Paris, whether for street washing or for drinking purposes, is now filtered and sterilized. During the war this was not the case, as we used the impure Seine River water for experimental work in our Paris laboratory. During the war we found the Paris water to be of most excellent quality and with the precautions taken at the additions to the plant, it is our opinion that no water in the world is of any greater purity than that furnished to the city of Paris.

SOFTENING A WELL WATER SUPPLY[1]

By N. T. Veatch, Jr.,[2] and B. L. Ulrich[3]

The water treatment plant at Manhattan, Kansas, offers a good example of the practical treatment of a hard, iron laden, well water.

The raw water at Manhattan is obtained from four wells and has the characteristics shown in table 1.

The water treated is a fairly uniform mixture since the wells are pumped in rotation for thirty minute periods, and ample time for mixing is afforded at the plant. Its chemical characteristics are, therefore, as follows:

	p.p.m.
Alkalinity	412
Non-carbonate hardness	15
Total hardness	463
Iron	12
Free CO_2	75.8

These characteristics have been found to vary very little and, as a matter of fact, the variation is so small that routine tests of the raw water are now made at very infrequent intervals.

The treatment plant is designed to operate at a rate of 2 m.g.d. and consists of pan type aerators with a total weir length of 210 feet, two mixing basins each with a capacity of 30 minutes flow, and fitted with mechanical agitators, settling basins with a total capacity of 6 hours flow, and four standard 0.5 m.g.d. rapid sand filter units. Dry feed machines for feeding hydrated lime and powdered alum are in use, and in September, 1929, apparatus for producing carbon dioxide from the combustion of natural gas was installed.

The plant is operated intermittently in accordance with the demands of the city, but at a constant rate of flow. It was put in service in February, 1923, and was successful in removing the iron and in partial softening, but it was found that the softening process was very definitely limited by the necessity of keeping caustic water out

[1] Presented before the Missouri Valley Section meeting, November 7, 1930.

[2] Of Black and Veatch, Consulting Engineers, Kansas City, Mo.

[3] Water Superintendent, Manhattan, Kans.

of the mains. The removal of about 298 p.p.m. of hardness or, in other words, the reduction of the hardness to approximately 165 p.p.m. was found to be about the limit possible without recarbonation, and at this rate of treatment it was found that the addition of 2.59 grains of alum per gallon was insufficient to prevent after-precipitation in the mains and water meters, while the addition of more alum than this caused such a heavy floc on the filters that the runs were made very short.

In view of the fact that the control of causticity with alum was expensive and since there was a demand for softer water, recarbonation equipment was installed in 1929.

The addition of carbon dioxide previous to filtration has enabled the alum treatment to be reduced from an average of 2.59 to 0.52

TABLE 1

Chemical characteristics of well waters at Manhattan, Kansas

(Results in parts per million)

WELL NUMBER	ALKALINITY	NON-CARBONATE HARDNESS	TOTAL HARDNESS	IRON	FREE CARBON DIOXIDE	PORTION OF TOTAL SUPPLY, PERCENT
1	519	28	547	16.8	101	16.7
2	392	60	452	8.5	68	16.7
4	435	30	465	15.3	81	33.3
5	345	80	425	9.3	61	33.3

grains per gallon and has made it possible to add enough lime to reduce the hardness of water to 124 p.p.m. which, in this case is nearly the limit possible with lime alone.

The operating data for eight months previous to and for eleven months after the installation of recarbonation are tabulated in table 2.

Table 2 is interesting in that it shows that the cost of softening with recarbonation is approximately 5 percent lower per unit of hardness removed, and that filter runs have been increased by approximately 25 percent. Recarbonation has also made it possible to remove approximately 13.5 percent more hardness without the necessity of using alum in large amounts to correct causticity and without the danger of after-precipitation in the distribution system.

The recarbonation equipment is simple since it consists merely of a gas burner, a coke scrubber, an air compressor and a condensa-

tion trap. Its operation is also simple since the amount of carbon dioxide produced may be regulated by the gas valve on the burner.

TABLE 2

Operation of water softening plant at Manhattan, Kansas, January 1, 1929, to July 30, 1930

MONTH AND YEAR	1,000's OF GALLONS TREATED	CHEMICALS USED, GRAMS PER GALLON		TOTAL HARDNESS, P.P.M.		NATURAL GAS USED 1000, CU. FT. P.M.G.	COST OF CHEMICALS, DOLLARS P.M.G.	1,000's OF GALLONS FILTERED BETWEEN WASHES PER FILTER
		Alum	Lime	Treated water	Removed			
Before recarbonation								
January, 1929	29,336	2.72	22.40	160	303	—	32.82	337.2
February, 1929	27,548	2.89	22.45	160	303	—	32.96	367.3
March, 1929	30,087	2.69	22.10	161	302	—	32.01	362.5
April, 1929	30,700	2.68	22.38	161	302	—	32.03	344.9
May, 1929	32,100	2.48	22.73	164	299	—	32.60	406.3
June, 1929	31,483	2.66	22.90	166	297	—	32.84	338.5
July, 1929	38,192	2.56	22.92	170	293	—	32.62	353.5
August, 1929	37,075	2.04	22.72	168	295	—	31.06	436.2
Total	256,521	20.72	180.60	1,310	2,394	—	258.94	2,946.4
Average	32,085	2.59	22.57	165	298	—	32.37	368.3
After recarbonation								
September, 1929	34,482	0.73	26.52	124	339	2.08	34.24	405.6
October, 1929	34,178	0.65	26.06	133	330	2.10	33.62	402.1
November, 1929	30,609	0.55	26.99	128	335	2.11	34.78	364.4
December, 1929	30,615	0.45	27.09	131	332	2.17	34.57	460.4
January, 1930	30,978	0.41	25.80	136	327	2.29	33.19	499.6
February, 1930	30,412	0.50	26,47	115	348	2.32	33.94	416.6
March, 1930	33,880	0.58	28.50	119	344	2.61	36.48	408.2
April, 1930	34,506	0.48	28.52	114	349	2.40	36.13	401.3
May, 1930	34,301	0.53	28.27	125	338	2.22	35.92	612.5
June, 1930	34,787	0.44	28.67	118	345	2.31	35.85	527.0
July, 1930	51,485	0.43	25.40	125	338	2.29	33.16	605.0
Total	380,233	5.75	298.29	1,368	3,725	25.00	381.88	5,102.7
Average	34,566	0.52	27.11	124	338	2.27	34.81	463.8

The operator makes frequent alkalinity tests and maintains from 5 to 20 p.p.m. of hydroxide in the water before recarbonation and by regulating the gas valve maintains less than 16 p.p.m. of carbonates in the filtered water.

There is, of course, nothing novel in the matter of softening a well water and removing the iron from it by aeration, lime treatment and filtration and the chief point illustrated by the Manhattan experience is the necessity of recarbonation if softening beyond a certain point is desired.

The relatively high cost of correcting causticity and excess normal carbonates by the use of alum is also demonstrated very plainly here since the use of 2000 cubic feet of gas, which cost approximately $1.00, per million gallons, has enabled a saving of approximately 2 grains per gallon of alum, which cost approximately $4.00 per million gallons, and permitted the use of the additional lime required to soften the water to the desired point.

It is to be noted that the non-carbonate hardness in this instance is relatively low and hence lime softening is unusually adaptable. If, for instance, the water contained twice the non-carbonate hardness, it would be impossible to get these results without the use of soda ash or Zeolite and the matter of recarbonation would be of still more importance.

CONSERVATION BY METERING[1]

By F. R. Vannoy[2]

Prior to the year 1912, Madisonville, Kentucky, depended for its water supply upon a private water company, operated in connection with an ice plant.

In the summer of the same year an attempt was made to secure a supply from deep wells, which proved unsuccessful, and in the winter of 1912–13, the city leased approximately 500 acres of timbered land containing three possible developments, for its water supply from artificial lakes.

After consulting competent engineers the necessary preliminaries were begun and a contract was let for the construction of a dam, pumping station, and distribution system. By May 1, 1914, the city began using water from its new supply. It was found, however, that in the event of a dry year, it would be necessary to develop a second lake as a reserve and it was recommended to begin at once on Lake No. 2, and by October, 1915, Lake No. 2 was completed with connection to pumping station.

At this time there were 390 patrons being served from the new plant, from which the city derived $6500.00 annually.

As the consumption increased, the dams of both lakes were raised, increasing the impounding capacity and giving the city two reservoirs of 90 million gallons each. The foregoing is a brief outline of the events leading to our present water supply.

Until the year 1925, with the exception of a few commercial and industrial users, all patrons were being served on a flat rate basis. As an experiment, it was decided to adopt a meter program, it being the most equitable for the consumer as well as the water plant.

It may be remembered that the rainfall for the winter and spring of 1924–25, generally speaking, was far less than it had been for several years previously, and by June 1, 1925, the city was practically without water. Immediately work was begun on an emergency pipe

[1] Presented before the Kentucky-Tennessee Section meeting, January 24, 1929.

[2] Superintendent, Municipal Light and Water Company, Madisonville, Ky.

line and a booster pumping station, making a connection with a nearby town. The cost of this installation was borne entirely by revenue derived from the operation of the city's light and water system. A contract was entered into for one year and water was supplied to our booster pumping station located some two miles from the distribution system, at a rate of 10 cents per thousand gallons for the first hundred million, and 7.5 cents per thousand for all over, during the life of the contract. Since the cost of power for pumping amounted to 2.5 cents per thousand gallons, not allowing for any other fixed charges, we were confronted with a problem to deliver water to the larger users, who had been previously contracted with, at a rate lower than it was costing to put the water into the mains.

This emergency impressed us with a number of reasons why our limited supply should be conserved to the greatest extent; first, to care for the consumption in dry years; second, to provide for the increasing number of consumers and their ultimate consumption; and last, to protect against wanton extravagance, as our two lakes already had been enlarged to their maximum impounding capacity.

The consumption per capita per day at this time approximated 75 gallons, which was comparatively low, due to not having a large number of industrial users. However, we found from periodical inspections that a large number of customers had leaks in their various fixtures which were next to impossible to control on a flat rate basis.

The seriousness of a leak of a half a gallon a minute through an orifice smaller than a lead in a pencil, is seldom realized, but a simple calculation will show that such a leak amounts to 720 gallons a day, or 262,800 gallons per year. If we assume that 5 percent of the toilets leak on an average of a half a gallon a minute, a low estimate, when unmetered premises are considered, the loss of water from this source would reach the astounding amount of over three million gallons per year per one thousand inhabitants. Aside from waste through other fixtures, there are broken underground pipes, water motors, pumps operated by water to remove seepage from basements, defective stop and waste cocks, water wasted to obtain a cool drink, children leaving faucets open, lawn sprinkling without nozzles, the flushing of toilets after use for purposes which they are not intended such as garbage recepticles, and, last, allowing water to run continuously in cold weather to prevent freezing. The majority of these leaks, we believe, could be controlled by metering.

METERING PROGRAM

As has been previously mentioned, only a small number of meters were in service. They were all, however, of the same make and the product of a well-known manufacturer. Therefore, it was considered wise to contract for the same meter. We at once contracted for a thousand $\frac{5}{8}$ by $\frac{3}{4}$ meters, this size being adopted as standard for residences and other small consumers. We also purchased a quantity of oval water meter boxes, 12 by 18 by 18 inches with a non-locking type lid. We found that a saving could be effected by putting the curb stop just inside the meter box except in such cases where larger meters than one inch were used.

Meters were installed as rapidly as possible. Since a large street improvement program was under way, it was necessary to renew all water services, which was done in lead, and with our regular crew, installations were made with little additional cost. The foremost thought was to combat a recurrence of the water famine, as resources were not available at that time to provide additional lakes on account of the inability to float a bond issue, requiring a vote of the people. However, relief measures in such cases were provided for by our state legislature in 1926, which adopted a bill permitting municipalities to bond their water systems.

As the installation of meters progressed a meter department was created, having one man to read and repair all meters and be responsible for all transfers. A card index system was kept of all installations which included the name of the property owner, number and size of the meter, date of installation, size and type of service, and any other information that would be useful for future reference. We contemplate the installation of a test table when conditions warrant the purchase of same. At the present time, the meter man is provided with a portable kit containing a quantity of small repair parts, consisting of change gears, register box glasses, discs, etc. And in a great number of cases small repairs can be made without removing the meter to the shop.

The report of January 1, 1926, showed that 303 meters had been installed, the results so far being very satisfactory. It was found that customers who formerly paid $1.90 per month for a bath, kitchen sink, and lawn hydrant, for a family of five, were now paying from $2.80 to $3.50 per month. On the other hand, for the same number of fixtures, a family of two, would seldom use above the minimum of $1.10 per month. It was also noted that complaints of

abnormal consumption when investigated would result in the finding of some one of the leaks which I have mentioned, amounting in some cases to as much as 6000 or 7000 gallons per month.

The report of January 1, 1927, showed the system to be 77 percent metered, and that approximately 15 percent less water had been pumped than in the previous year. Contrasting the reduction in consumption, it was interesting to note that the receipts from the operation of the plant showed an increase of $513.81, notwithstanding the loss of 91 customers during the year, which was accounted for by the fact that the installation of meters made a single customer in instances where formerly as many as two or three flat rates were paid for service rendered through a single tap.

The report of January 1, 1928, showed that 1606 customers were being served, an increase of 67 over 1926, the system then being 100 percent metered. It was estimated that a saving of 100,000 gallons of water per day had been effected. It was also found that the receipts from the sale of water showed an increase of $975.00 over the previous year.

As of January 1, 1929, the water plant is now serving 1659 customers, an increase of 53 over last year. The receipts from the sale of water show an increase of $1903.79 over the previous year. Summarizing the results of metering we find that all customers so far as we are able to determine, seem to be thoroughly satisfied with the metered system, feeling that they are justly charged for water which they consume. There has been a substantial increase in the water receipts each year and the conservation of our very limited supply has far exceeded our expectations, thus enabling us to plan more deliberately and thoroughly for a permanent and adequate supply in the near future.

PROJECTS FOR STANDARDIZATION

The American Standards Association, concerned with a program for standardization in the mechanical industries, has under consideration the completion of projects now in process. These projects are listed below. The Standards Association requests the views of members of the American Water Works Association as to which of these projects should be given priority for completion in the next year. Our members are requested to communicate on this subject with Mr. A. V. Ruggles, American Water Works Association, 29 W. 39th Street, New York City.

AMERICAN STANDARDS ASSOCIATION

Projects in process

A Air Cylinders and Adapters for Chucks
B Bars; Cold Finished Iron and Steel
Bearings; Thrust Ball
Belting; Leather
Bolts; Stud
Bushings; Drill
C Chains; Silent
Chucks and Chuck Jaws
Couplings; Flanged Shaft
D Drills; Twist, Sizes
Dies; Electric Welding and Electrode Holders
F Flange Dimensions; Facings and Boltings for pressure-containing joints:
Cast Iron, 25 lb. Steam Pressure
Cast Iron, 800 lb. Hydraulic Pressure
Steel, 150–120 lb. Steam Pressure
Steel, 1500 lb. Steam Pressure
Steel, 2500 lb. Steam Pressure
Steel, 3500 lb. Steam Pressure
G Gages; Wire and Sheet Metal
Gages and Methods of Gaging
Gages and Gaging of Screw Threads

Gages; Pressure and Vacuum
Gears; Helical
Gears; Worm
Gears; Inspection
Gears; Materials
Gears; Bevel
H Holders; Punch and Die
M Manhole Frames and Covers
Motors; Electric, Frame Dimensions
P Pins; Cylindrical
Pins; Taper
Pins; Split
Pipe and Fittings, Cast Iron Soil
Pipe Fittings; Flanged:
Cast Iron, 25 lb. Steam Pressure
Cast Iron, 800 lb. Hydraulic Pressure
Steel (Companion or Loose Flanges) for various steam pressures
Steel, 150–120 lb. Steam Pressure
Steel, 1500 lb. Steam Pressure
Steel, 2500 lb. Steam Pressure
Steel, 3500 lb. Steam Pressure
Steel Base, 250, 400, 600 and 900 Steam Pressure
Ammonia, Iron and Steel
Pipe Fittings, Brass for Flared Copper Tubes
Pipe Unions; Malleable Iron and Steel for High Pressure
Pipe; Cast Iron and Special Castings
Pipe Plugs; Cast Iron and Steel
Pipe and Tubing; Wrought Iron and Steel, High and Low Temperature
Piping, Pressure; Power, Hydraulic, Gas and Air, Refrigerating, and Oil
Plumbing Fixtures; Porcelain, China and Enamel
Plumbing Products; Brass
R Rivets, Large
S Screws, Socket Head Cap and Set
Screw Threads; for Hose Couplings, other than Fire Hose
Screw Threads, Rolled; for Screw Shells of Electric Sockets and Lamp Bases
Screw Threads; Straight Pipe

Screw Threads; Plumbers
Screw Threads; Thin Tubes
Screw Threads; Rigid Electrical Conduit
Spindle Noses and Collets
Splines and Splined Shafts
T Tables; Milling Machine
Tapers; Machine
Tools, Machine; Designation and Working Ranges
Traps; Brass Lavatory and Sink
Traps, Cast Iron
Traps; Catch Basin
Traps; China
Traps; Interceptor
Traps; Lead
Traps: Miscellaneous
V Valves; Ferrous Flanged, Face to Face Dimensions of
W Washers, Plain and Lock

DISCUSSION

THE EARLY USE OF CHLORINE

I have observed in the article commencing at page 1161 of the September issue of the Journal in the paper on "Recent Progress in the Art of Water Treatment," by Abel Wolman, Wellington Donaldson and Linn H. Enslow, a mention on the second page of the article as follows:

"Even the ubiquitous chlorine compounds were used for disinfection of water in 1902 in Belgium, 1905 in England and 1908 in this country."

On the subject of the early use of the process in Belgium I think it may be of interest to your Association to draw attention to the fact that the application in question was applied at the small waterworks at Middelkerke. The process employed in this little waterworks was invented by my old friend, Dr. Maurice Duyk, at that time Official Chemist to the Belgian Government. This small installation consisted of four gravity filters each comprising a cylindrical shell 5 feet in diameter. Above the filters a rectangular cistern was mounted in which bleaching powder was mixed and provided the chlorine by means of dripping cocks.

In addition to the chlorine, a similar dripping arrangement supplied perchloride of iron.

The result was in every respect successful. The water was drawn from a small stream of excessively polluted character. I have seen this water in the summer time when it looked like a brown sherry with no appearance of suspended matter. In the winter the water was to some extent turbid.

I have never observed a reference to Dr. Duyk in any account of chlorination treatment, although there can be little doubt that this modest installation was the commencement of the enormous volume of chlorine treatment which now exists throughout the civilised world.

Dr. Duyk at the present time lives in a very modest retirement at Petit Varst, Landenke, Meuse, Belgium, and I thought that possibly you might think it a graceful act to bring his name before your

Association for consideration as to whether any kind of acknowledgment might be made to this gentleman of the immense services to mankind which he initiated.

I may say that I have the highest respect and regard for Dr. Duyk. I have applied to him at times where his profound knowledge of the chemical treatment of water has been of assistance to me in my calling and like many accomplished scientific men he has always steadily refused to allow me to recognise his services in the form of a fee.

I may add with regard to the remark in the above mentioned paper that the use of chlorine was commenced in England in 1905, that in 1904 I introduced the subject in England. I constructed a sterilising apparatus on Dr. Duyk's principle for a waterworks in England in collaboration with the consulting engineer to the works. I delivered the apparatus to the site and was then informed by the Medical Officer of the district that he would refuse to allow any form of chemical treatment, so that although a certain amount of contamination was known to be present in the water, I was debarred by the limited foresight and education of the Medical Officer in question from being the pioneer of chlorination in this country.

WILLIAM BOBY.[1]

[1] Of William Boby and Company, Ltd., Water Purification Engineers London, England.

SOCIETY AFFAIRS

THE CALIFORNIA SECTION

The convention was called to order at Pasadena, California, on October 29, 1930, by President Chas. S. Olmsted and an address of welcome was given by Robert L. Dougherty, Chairman of the Board of Directors of the City of Pasadena.

A paper (illustrated) on "Pasadena Water Department," was presented by Samuel B. Morris, Superintendent and Chief Engineer, Pasadena Water Department. This was followed by a report of the Metropolitan Water District of Southern California, prepared and presented by F. E. Weymouth, Chief Engineer.

"The Protection of Water Mains Against External Corrosion," prepared by K. H. Logan, Electric Engineer, Bureau of Standards, Washington, D. C. was presented by I. F. Van Giesen.

"Electric Welded Steel Pipe Lines" was presented by F. W. Hanna, Chief Engineer and General Manager, East Bay Municipal Utility District, Oakland.

Fundamental Consideration in Determining the Cost of Rendering Public Fire Hydrant Service," by Edward B. Mayer, Assistant Engineer of the Department of Water and Power, Los Angeles.

October 29, 1930, 6:30 p.m., Business Meeting

Call for Committee Reports.

Report of the Secretary was received and adopted; report of the Treasurer was submitted and ordered audited and certified; moved by Mr. Klaus, seconded by Mr. Pracy, approved.

Mr. John Burt, Chairman of the Nominating Committee presented the following names for office for the year 1930–1931, they were approved.

Wm. W. Hurlbut, President.
Wm. F. Goble, Vice-President.
L. L. Farrell, Executive Committee.
Orla Casad, Executive Committee.
E. W. Green, Secretary-Treasurer.

The report of Wm. F. Goble, Chairman of the Executive Com-

mittee, on the selection of the city in which the 1931 convention will be held was made, presenting an invitation from the City of Stockton. Report was seconded by Mr. Trauger and the California Water Service officials, the Chamber of Commerce and the City Manager were notified as to the acceptance of their invitation.

The following resolution was presented by President Olmsted, ordered incorporated in the minutes of this meeting and a copy sent to the family of the deceased:

Be It Resolved: "Following the custom of our Association to pay our respects to those of our members who have passed to the Beyond.

"I propose that the members and guests here assembled rise in a silent tribute to one who spent a long and useful life among us, one who was loved by all who knew him, and respected by the many engineers and water works men who came in contact with him, and who passed to the Great Beyond on March 12, 1930." Claude I. Rhoades.

Certain changes as directed by Secretary B. C. Little were ordered made in the Association By-Laws by a Resolution Committee appointed by President Olmsted and composed of Wm. W. Hurlbut, Chairman, S. B. Morris and Carl Wilson.

The following papers were presented on October 31.

"Water Rights," by W. G. Irving, Attorney, Riverside.

"Development of Deep Wells," by Rosco Moss, Los Angeles.

"Development of Deep Wells," by D. A. Lane, Bureau of Water Works and Supply, Los Angeles.

"Colorado River Project," by Professor Creighton O. Waldorf, Beverly Hills.

"Reclamation of Treated Sewage," by R. F. Goudey, Sanitary Engineer, Bureau of Water Works and Supply, Los Angeles.

"Corrosion Problems," by I. F. Van Giesen, Electrolysis Engineer, Bureau of Water Works and Supply, Los Angeles.

"Relation of Politics to the Management of Municipally Owned Water Systems," by Fred M. Randlett, Pacific Coast Manager, Robert W. Hunt Company, San Francisco.

"Stand-By Charges for Water Service," by C. E. Thatcher, Manager Commercial Department, East Bay Municipal Utility District, Oakland and presented by Carl Forgey, Engineering Department, East Bay Municipal Utility District, Oakland.

"Billing and Collection Methods," by Carl K. Chapin, Pasadena.

"Cost Keeping and Budget Control," prepared by F. M. Faude, Loveland Engineers, Inc., San Francisco and presented by Harry Reinhardt, Loveland Engineers, Inc., San Francisco.

"Distribution Reservoir Design," by Chester A. Smith, of Burns, McDonnell and Smith, Consulting Engineers, Los Angeles.

Members and guests were the guests of the American Water Works Manufacturing Association at a dinner dance held at the Hotel Huntington at which time the prizes were awarded to those participating in the Golf Tournament held at the Flintridge Golf Course on Wednesday, October 29, 1930.

Following the banquet, the meeting adjourned.

L. L. FARRELL,
Secretary.

THE MISSOURI VALLEY SECTION

The sixteenth annual meeting of the Missouri Valley Section was called to order by Vice-Chairman, H. V. Pedersen in the Roosevelt Room in the Hotel Roosevelt at Cedar Rapids, Iowa at 10:30 a.m. on November 5, 1930. There were fifty persons present in the room. Honorable Chas. D. Huston, Mayor of Cedar Rapids, officially welcomed the Section to Cedar Rapids. Mr. H. F. Blomquist, Superintendent of Waterworks, welcomed the Section on behalf of the Cedar Rapids Water Department. Mr. H. V. Pedersen, Superintendent of Water Works at Marshalltown, Iowa, Vice-chairman of the Section, responded to the addresses of welcome on behalf of the Section and expressed the pleasure of the Section in having the opportunity to meet in Cedar Rapids.

The Secretary then read a telegram from Thomas J. Samuel, Jr., Superintendent of the Water Department at Kansas City, Missouri, Chairman of the Section, expressing regret that owing to circumstance over which he had no control he could not attend the Cedar Rapids meeting. Vice-chairman Pedersen then announced the appointment of the following committees:

Resolutions Committee. Chairman—J. Chris Jensen, Trustee of Water Works, Council Bluffs, Iowa; Thomas J. Skinker, Engineer in charge of Distribution, Water Department, St. Louis, Missouri; J. A. Strang, District Manager, Wallace & Tiernan, Kansas City, Missouri.

Auditing Committee. Chairman—John W. Pray, Superintendent of Water Works, Fort Dodge, Iowa, and Mr. H. D. Peters, Assistant Engineer, State Board of Health, Jefferson City, Missouri.

The Secretary then read a communication from Mr. Beekman C. Little, Secretary of the American Water Works Association suggest-

ing certain amendments to the Constitution of the Missouri Valley Section in order to bring it into conformity with the recommendations of the A. W. W. A. Committee on Section By-Laws. These suggestions were as follows:

It is requested that all the Sections' rules are called "By-Laws," rather than "Constitutions."

In Article III of your By-Laws it is requested that it read "The headquarters of this Section shall be at the office of the Secretary-Treasurer for the time being."

In Article IV after the word "South Dakota" have it read "and all those residing in the State of Nebraska east of a line represented by 100 degrees longitude west."

In Article V, Section I, in the second sentence after the word "officers" insert "with, exofficio, the Section Director of the American Water Works Association," etc.

In Section 3 of Article V insert the phrase "by ballot" after the word "elected." Also, add a Section 5 to Article V reading: "At the proper three-year intervals at an annual meeting of this Section those members present shall nominate and elect a Director to represent the Section on the Board of Directors of the American Water Works Association, in accordance with Article IV, Section 2, of the Constitution of the Association."

Change Article VIII so that it reads: "Such amendment shall be in effect after approval by the Board of Directors of the American Water Works Association," and change the word "Constitution" to read "BY-Laws" as before suggested.

Upon motion duly seconded and carried this matter was referred to the Executive Committee for report at the business session.

The meeting then proceeded to take up the topics listed for Round Table Discussion. Topic 1, "Water Works Troubles during the Past Year" was opened for discussion by William Molis, Superintendent of Water Works at Muscatine, Iowa. The discussion was participated in by John W. Pray; Phil Carlin, Superintendent of Water Works at Sioux City, Iowa; W. Scott Johnson, Chief Public Health Engineer, State Board of Health, Jefferson City, Missouri; G. E. Shoemaker, General Manager of Water Works, Waterloo, Iowa; August G. Nolte, Chemical Engineer, Chain of Rocks Plant, St. Louis, Missouri; Thomas J. Skinker, St. Louis; and H. V. Pedersen.

Mr. John W. Pray opened the discussion on Topic 2, "What shall be done for old employees when they become unfit for active service?" After further discussion by Thomas Maloney, Water Works Trustee, Council Bluffs, Iowa; J. W. McEvoy, Superintendent of Water Works, Dubuque, Iowa; John C. Detweiler, Superintendent of

Water Works, Metropolitan Utilities District, Omaha, Nebraska; Joseph S. Nelson Commissioner of Water Works, Sioux Falls, South Dakota; J. Arthur Jensen, Supervisor, Water Works Department, Minneapolis, Minnesota; and L. A. Day, Water Commissioner, St. Louis, Missouri; it was moved by Mr. Maloney and seconded by Mr. Carlin, that the chairman appoint a committee composed of members from the different states included in the Missouri Valley Section to consider and recommend proposed legislation which would provide legal means for caring for old employees of water works departments. The motion was unanimously carried.

Topic 6, "Algae Troubles" was opened for discussion by Frank Raab, Chemist and Bacteriologist at the Fridley Filtration Plant, Minneapolis, Minnesota. Mr. Raab read a very interesting paper describing algae troubles encountered at Minneapolis during the past summer. Messrs. August Nolte, William Molis, Phil Carlin, W. Scott Johnson and J. W. McEvoy, took part in the discussion of this paper.

The meeting adjourned at 12:10 noon.

A meeting of the Executive Committee was held at 1:20 p.m. November 5, 1930. There were present Messrs. Pedersen, Johnson, Brown, Jensen, Nelson and Waterman. After consideration it was voted to recommend to the Section the adoption of changes in the Constitution of the Missouri Valley Section as suggested in the communication from Mr. Beekman C. Little, Secretary of the A. W. W. A. The meeting of the Executive Committee was then adjourned.

The afternoon session of Wednesday, November 5, was opened by Vice-Chairman Pedersen at 2:15 p.m. The nominating committee which consisted of Jack J. Hinman, Jr., Chairman, Thomas J. Skinker, and Rhea Rees reported the following nominations for officers of the Section for the ensuing year. They were later elected.

Chairman—H. V. Pedersen, Manager of Water Works, Marshalltown, Iowa

Vice-Chairman—H. L. Brown, Superintendent Water Works, Salina, Kansas

Directors:

For Iowa—George J. Keller, Manager Water Works, Iowa City, Iowa

For Kansas—Earnest Boyce, State Sanitary Engineer, Lawrence, Kansas

For Missouri—Aug. G. Nolte, Chief Chemical Engineer, Chain of Rocks Plant, St. Louis, Missouri

For Nebraska—John C. Detweiler, Superintendent of Water Works, Metropolitan Utilities District, Omaha, Nebraska

For South Dakota—Joseph S. Nelson, Water Commissioner, Sioux Falls, South Dakota

The report was received and further action deferred until the business meeting of the Section.

The first paper on the program, "What Should a Water Works Superintendent Make of His Job?" was read by the author, W. Scott Johnson, and discussed by J. J. Hinman, Jr., J. Arthur Jensen, and H. V. Pedersen. Mr. J. P. Houser, Assistant Sanitary Engineer, State Department of Health, Des Moines, Iowa, presented a paper on "Surveys of Iowa Water Supplies" which was discussed by W. L. Meeker, Superintendent, Water Works Co., Clinton, Iowa; W. Scott Johnson; Earle L. Waterman, Iowa City, Iowa; and Jack J. Hinman, Jr. Dr. C. O. Bates, Chemist, Water Department, Cedar Rapids, Iowa, presented a paper on "Preliminary Tests for the Softening of Water from the Cedar River." This paper was discussed by Floyd A. Nagler, Professor of Hydraulic Engineering at the University of Iowa, Iowa City, Iowa, and Edward Bartow, Head of the Chemistry Department at the University of Iowa.

The meeting then proceeded to a continuation of the Round Table discussion taking up Topic 4, "Unusual Floods and the Water Works Plant." This topic was discussed by H. F. Blomquist, Floyd A. Nagler, L. R. Howson, W. Scott Johnson, W. L. Meeker, Edward Bartow, and Lafayette Higgins. The meeting adjourned at 5:20 p.m.

The evening meeting on Wednesday, November 5, was called to order by Vice-Chairman Pedersen at 8 p.m. A general invitation had been extended to the public to be present and there were about 200 people in attendance. Mr. Joseph S. Nelson, Water Commissioner, Sioux Falls, South Dakota, gave a very interesting illustrated lecture on "Water and Its Relation to Health." Mr. L. R. Howson, member of the firm of Alvord, Burdick, and Howson, Consulting Engineers, Chicago, Illinois, presented a paper entitled "The New Water Purification Plant at Cedar Rapids, Iowa." After some informal discussion the meeting was adjourned at 10:05 p.m.

On Thursday, November 6, at 9:00 a.m. those attending the meeting visited the old water purification plant and pumping station of the Cedar Rapids Water Works Department. This plant furnished the water supply for the city of Cedar Rapids until October 1930 when

the new purification plant was put into service. After inspecting the old plant, the party was taken by busses to the New Cedar Rapids Water Purification and Pumping Plant. These inspections were made under the direction of Mr. H. F. Blomquist, Superintendent of Water Works and members of his staff. Luncheon was served in the Filter Room at the Water Purification Plant, following which the party returned to the Hotel Roosevelt.

The Thursday afternoon session was called to order by Director H. L. Brown, Superintendent of Water Works, Salina, Kansas, at 2 p.m. The appointment of the special committee on legislation to look into the matter of pensions for water works employees was announced. It was constituted as follows: Thomas Maloney, Chairman, J. S. Nelson, L. A. Day, John W. Pray, Phil Carlin, George Shoemaker, W. L. Meeker.

Daniel H. Rupp, Filtration Engineer, Topeka, Kansas, presented a paper entitled "Water Purification at Topeka," This paper was discussed by August Nolte, J. J. Hinman, Jr., and F. M. Veatch of Kansas City, Missouri. A paper on "Water Softening Practice" was presented by Charles P. Hoover, Chemist in Charge, Water Softening and Purification Works at Columbus, Ohio. It was discussed by Daniel H. Rupp, F. M. Veatch, Earle L. Waterman, C. O. Bares and Frank Bachmann. Mr. H. V. Pedersen presented a paper on the subject, "Locating a Water Supply by Means of a Water Witch' which was discussed by John W. Pray, Jack J. Hinman, Jr., and Edward Bartow. Mr. A. H. Wieters, Chief Engineer, Division of Sanitary Engineering, State Department of Health, Des Moines, Iowa, presented a paper entitled, "Delivery of a Safe Water to the Consumer;" discussed by Jack J. Hinman, Jr., Charles P. Hoover, and Lafayette Higgins. Mr. Everett R. Mathews, Assistant Water Analyst, University of Iowa, Iowa City, read a paper written by Mr. Jack J. Hinman, Jr., and himself on "The Colorimetric Determination of Iron in Water." This paper was discussed by Charles P. Hoover.

The meeting adjourned at 5:05 p.m.

The annual dinner was served in the Cedar Rapids Chamber of Commerce dining room at 6:30 p.m. Thursday, November 6th. Following the dinner the gathering was addressed by Beekman C. Little, Secretary of the American Water Works Association who outlined some of the current activities of the A. W. W. A.

There were 25 people present when Vice-Chairman Pedersen

called the meeting on Friday morning, November 7th, to order. Dr. Edward Bartow presented a paper on the subject, "Observations of Foreign Water Supplies," which was discussed by Daniel H. Rupp. The paper entitled "Softening a Well Water Supply," written by N. T. Veatch, Jr., of Kansas City, Missouri, and B. L. Ulrich, Superintendent of Water Works at Manhattan, Kansas, in the absence of the authors was read by F. M. Veatch and discussed by Edward Bartow, H. V. Pedersen, and William J. Schneider. Mr. R. W. Kehr, Assistant Engineer, State Board of Health, Lawrence, Kansas, presented a paper entitled "Some Observations of Dental Deficiencies Correlated with Chemical Studies of Drinking Water" which was discussed by W. L. Mecker and Earle L. Waterman.

The meeting was then resolved into the business session of the Missouri Valley Section. The Auditing Committee submitted its report.

The following resolutions were adopted:

WHEREAS: (1) The Missouri Valley Section of the American Water Works Association in its 16th annual convention at Cedar Rapids, Iowa has enjoyed a most instructive and entertaining meeting, and

(2) The Convention is indebted to the officials and the city of Cedar Rapids for their cooperation and contributions to the success and pleasure of the meeting.

Resolved: (1) That the Missouri Valley Section of the A. W. W. A. express to Mayor C. D. Huston and the City of Cedar Rapids its thanks and appreciation for their cordial greeting and warm hospitality and congratulate the city upon the recent completion of its new water purification plant.

(2) That the Section further express to Mr. H. F. Blomquist and the Water Department of Cedar Rapids (its appreciation of their entertainment and their hearty cooperation.

(3) That the Section also thank Mr. H. R. Green for his active interest and compliment him on his arrangements for a most enjoyable banquet.

(4) That copies of this Resolution be sent to Mayor Huston, Mr. Blomquist and Mr. Green with the request that they communicate the sentiments of the Section to all those who so ably assisted them in making the meeting a success.

WHEREAS: The 16th Annual Meeting of the Missouri Section of the A. W. W. A. was deprived of the guidance and counsel of its chairman, Mr. Thomas D. Samuel of Kansas City, because of illness which prevented his attendance.

Resolved: (1) That the Section express to Mr. Samuel the regret of the members at his enforced absence and their thanks for his efforts during the past year.

(2) That a copy of this Resolution be sent to Mr. Samuel with the wish of all members for his prompt and complete recovery.

WHEREAS: Through the untimely death of Past President Homer V. Knouse of Omaha, the Missouri Valley Section of the A. W. W. A. has within the past year lost one of its oldest members, a staunch supporter and a true friend.

Resolved: That the Missouri Valley Section of the A. W. W. A. in Annual Convention at Cedar Rapids, Iowa, express to Mrs. Knouse and family the condolence and sympathy of the members of the organization.

WHEREAS: The Missouri Valley Section of the A. W. W. A. has through the recent death of Mr. Price D. Simms of Chicago, lost a loyal and congenial member, and valued associate.

Resolved: That the Missouri Valley Section of the A. W. W. A. in Annual Convention at Cedar Rapids, Iowa, express to his son, Mr. Simms, the sincere sympathy of the members of the organization.

WHEREAS: (1) The continuous measurement of the water resources of Iowa is necessary for the development and protection of the Water supplies of most Iowa municipalities and hence for the safe-guarding of the health and welfare of the people of Iowa.

(2) And, the collection and publication of information on stream flow should be carried on by some state agency in cooperation with the U. S. Geological Survey.

Resolved: (1) That the Missouri Valley Section of the American Water Works Association, in Annual Convention at Cedar Rapids, Iowa, heartily endorse the request of the Iowa Geological Survey for an annual appropriation of $5,000 for the maintenance of this work.

(2) That a copy of this Resolution be sent to Mr. Oscar Anderson, Iowa State Budget Director, requesting that an annual appropriation of $5,000 for stream gaging work be included in the Iowa State Budget.

The Secretary read the proposed amendments to the Constitution of the Missouri Valley Section as suggested by the Secretary of the American Water Works Association and approved by the Executive Committee of the Missouri Valley Section. It was moved, seconded and unanimously carried that these amendments be adopted.

Invitations for the Section to hold its next meeting at Sioux Falls, Iowa, and Fort Dodge, Iowa, were received and referred to the Executive Committee.

The sixteenth annual meeting came to a close by adjournment at 11:40 a.m. on Friday, November 7, 1930.

A meeting of the new Executive Committee of the Missouri Valley Section was called by Chairman Pedersen immediately following the business session of the Section on Friday, November 7, 1930. There were present Messrs. Pedersen, Brown, Detweiler and Nelson.

It was moved, seconded and unanimously carried that the expenses

of the Secretary in connection with the Cedar Rapids meeting be paid from Section funds.

Mr. Earle L. Waterman of Iowa City, Iowa, was unanimously elected Secretary-Treasurer of the Missouri Valley Section for the ensuing year.

Chairman Pedersen brought up the question of allowing an honorarium to the Secretary which might be used toward defraying travelling expenses to the Annual Meeting of the American Water Works Association. After discussion the following motion was unanimously adopted. "That the Executive Committee allow $100 to the Secretary for his services during the past year. This amount to be used primarily in paying the Secretary's expenses to the National Convention."

After some discussion it was voted to submit the question of a meeting place for 1931 to a letter ballot of the Executive Committee.

The Executive Committee meeting was then adjourned.

EARLE L. WATERMAN,
Secretary.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

New Water Supply System for Fort Lauderdale. F. J. KEIS. Eng. News-Rec., 104: 310–4, 1930. An illustrated description of the new water purification and supply system of Fort Lauderdale. The supply, obtained from wells 90 to 125 feet deep, located 7 miles inland, is hard and highly colored and has a disagreeable taste. The treatment plant consists of an aërator, mechanical mixing chambers, 3 coagulation basins, carbonating chamber, six 1-million-gallon per day rapid sand filters, and chlorinating equipment. Lime is employed for softening and alum for coagulation. The CO_2 distribution system consists of wooden pipes perforated on the under side and covered with a layer of gravel. Hardness is reduced from 310 to 85 and color from 48 to 10. *B. coli* tests on the treated water are invariably negative. Carbonation has almost eliminated trouble formerly experienced from clogged meters and stuck valves due to deposits from the water. The former supply, which failed in 1925, was treated with lime only. A 24-inch cast iron supply main, 4 miles in length, and an entirely new distribution system were also constructed. Two river crossings were made with flexible joint pipe. All joints, except those at the river crossings, were made with leadite. The specifications limited the permissible leakage under 24-hour test at 100 pounds per square inch to 200 gallons per inch of pipe diameter per mile per day. The leakage averated 20 to 25 per cent of this amount about 30 days after joints were poured. The temporary plant employed while the new system was being constructed is used as a standby. The cost of the filter plant and pumping station, including the 8 wells, was $517,000 and the cost of the supply main and distribution system was $800,000.—*R. E. Thompson.*

Calculation of the Electric Conductivity of Water. J. H. LINSCHOTEN. Chem. Weekblad, 26: 198–202, 1929. From Chem. Abst., 23: 3999, August 20, 1929. Two graphical methods are described by means of which the electrical conductivity of potable water at 18° is obtained without calculations. The complete diagrams are given in the original paper.—*R. E. Thompson.*

---

[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

Protection of Boilers and Furnaces. M. SEILLAN. Rev. gén. élec., **24**: 79–82, 1928; Science Abstracts **31B**: 569. From Chem. Abst., **23**: 3829, August 20, 1929. The author refers to the advantages of graphite as an inert protective covering material for the interiors of boiler furnaces, etc. Hitherto, however, there has been difficulty in applying it to such purposes. Two new solutions have now been produced, "Neutron" and "Capol," by the use of which it is claimed that these difficulties have been surmounted. These contain graphite in a colloidal form and can be applied by brush or sprayer, like paint. Cases are mentioned where they have been applied with success.—*R. E. Thompson.*

Critical Study of Corrosion Tests. E. HERZOG and G. CHAUDRON. Chimie & industrie Special No., 335–42, February, 1929. From Chem. Abst., **23**: 3890, August 20, 1929. Results are given showing that the loss in weight of metal on corrosion is not sufficient indication of the change in mechanical properties: when there is even and uniform corrosion over the whole surface, the mechanical properties are not greatly affected, even with losses in weight of up to 20 per cent; in the case of corrosion by local action (pitting), fairly small losses in weight do not greatly affect the breaking load, but the elongation is considerably reduced and frequently also the resilience. The authors consider the decrease in elongation the most significant indication of local corrosion, though the stamping test may be used for convenience In the tensile strength test, locally corroded test pieces behave similarly to notched test pieces.—*R. E. Thompson.*

Hydrochemistry of the Upper Kama and Its Tributaries. A. TRIFONOV. Bull. inst. récherches biol. univ. Perm, **5**: 147–56, 1927: Biol. Abstracts **2**: 440. From Chem. Absts., **23**: 3999, August 20, 1929. A study of the water of the Kama River between Perm and the mouth of the Wischera and at the mouths of 7 of its tributaries supports the theory of the universal occurrence of chemical heterogeneity in the cross section of a flowing stream. The pH varied between 7.2 and 8.2 at different points, depending chiefly on the balance between acid and salts in the bicarbonate buffer system. Differences in the nature of the water of the tributaries are attributed to differences in the geological structure of the areas drained.—*R. E. Thompson.*

The Theory of Water Chlorination. E. RUNOV. Centr. Bakt. Parasitenk., II Abt., **77**: 21–38, 1929. From Chem. Abst., **23**: 3999, August 20, 1929. In ordinary chlorination not more than 2 per cent of the available chlorine is used in the oxidation of bacteria, the larger part being consumed by dead organic matter and salts. The amount of chlorine used by the bacteria cannot be determined directly in the usual dosage but only by extrapolation from larger doses. The influence of different electrolytes depends not only on their concentration but also on the dosage of chlorine. For small doses of chlorine the catalytic effects of the following salts increase in the order given: NH_4, Ca, Mg, K. For large doses of chlorine the order of increase is practically reversed: Ca(K), Mg, K(Ca), NH_4. No special action could be traced to any anion.—*R. E. Thompson.*

The Technic of Water Sterilization by Chlorine and Its Compounds. F. DIENERT. Ann. hyg. publ. ind. sociale, 1929, 65–87; cf. C.A. 22: 3008; 23: 2517. From Chem. Abst., 23: 3999, August 20, 1929. A critical discussion.—*R. E. Thompson.*

Water—Its Problems and Their Treatment. DUDLEY K. FRENCH. Chem. Obzor 4: 138–45 (145, English), 1929. From Chem. Abst., 23: 3999, August 20, 1929. A survey of American methods of water treatment.—*R. E. Thompson.*

Measurement of Stream Velocity by Use of Air Bubbles. Eng. News-Rec., 103: 921, December 12, 1929. A method of determining the velocity of water flow in a stream or open channel by measuring the horizontal travel of an air bubble has been developed by OTOROGO MIYAGI, of Tohoku Imperial University, Japan. It was found that bubbles rising through flowing water attain a terminal velocity that is only slightly affected by the bubble size and that this velocity is in effect after the bubble has traveled an average distance of 3.5 cm. The method consists of introducing air from an air bottle below the surface of the water through a small glass tube nozzle. While rising because of its buoyancy, the bubble is also carried along horizontally by the flowing water. The point at which the bubble arrives at the surface is determined with the aid of glass plate with fine scale divisions printed on it, set just in contact with the water surface. The bubble size can be determined by measuring the volume of a number of them collected in a glass tube inverted over the nozzle. When the bubble size is greater than 0.3 cm. the formula employed is:

$$v = \frac{(7.1\ r + 17.8)\ l}{Z_o + 3.5}$$

where v = stream velocity in centimeters per second; r = bubble radius in centimeters; l = longitudinal displacement of the bubble in centimeters; and Z_o = depth of submergence of the air nozzle, in centimeters. The error introduced by neglecting the increase in size of the bubble as it rises is very small.—*R. E. Thompson.*

Determining Stream Velocity by Air Bubbles. KENNETH ALLEN. Eng. News-Rec., 104: 120, January 16, 1930. The principle of the method described in the previous abstract was described under the caption "A New Current Meter" in The American Engineer of February 18, 1882, by LUIGI D'AURIA, who developed it while in the employ of the water department of Philadelphia. The apparatus consists of a pontoon or float anchored at the desired location, from one side of the upstream end of which a rod, secured in a vertical position, is lowered until entering the streambed. An endless cord passes around pulleys near the top and bottom of the rod, by which a ball, whose specific gravity has been adjusted to half that of water, is carried to the bottom and released. The ball rises with a uniform velocity and is caught at the surface by floating grillage of wires stretched across a wooden frame, which is attached to the side of the downstream end of the float. The mean velocity is then found by dividing the distance from the vertical to the point reached by the ball by

the time of its ascent as determined by a stop-watch. By a rather elaborate computation and assuming the specific gravity of the ball as one-half that of water, the time in seconds is shown to be $0.0314d + 0.058$, in which d is the vertical distance the ball travels. With $d = 30$ feet and the velocity 4 feet per second, the horizontal distance traveled would be about 44 feet, requiring a pontoon not over 60 feet long. The advantages claimed for this method over the current meter, especially in tidal streams, were that it is reliable, that it can be used by men of ordinary capacity, and that it is less expensive.—*R. E. Thompson.*

Experiments on Sedimentation. K. S. VENKATARAMANAN. Bull. Mysore Eng. Assoc., 6: 3, 15–21, 1928. From Chem. Abst., 23: 3999, August 10, 1929. A method is described for determining turbidity of small samples which consists of lowering a coin and observing the disappearance of the lettering on the coin. The author also discusses further experiments carried out to determine the effect of soda ash and turbidity on settlement as compared with mechanical agitation.—*R. E. Thompson.*

Influence of Quality of Water on Industry. EDWARD BARTOW. Chem. Bull. (Chicago), 16: 191–2, 198, 218, 1929. From Chem. Abst., 23: 4000, August 10, 1929. A discussion of, and of methods of preventing, scale formation, corrosion, foaming, and embrittlement in boilers.—*R. E. Thompson.*

Preparation and Use of Particularly Saline Ground Water. K. HOFER. Glückauf, 64: 669–72, 1928. From Chem. Abst., 23: 4000, August 10, 1929. Analyses and precautions to be used for boiler feed water in the Ruhr district.—*R. E. Thompson.*

Pollution of Abandoned Well Causes Fond du Lac Typhoid Epidemic. L. F. WARRICK and E. J. TULLY. Eng. News-Rec., 104: 410–1, March 6, 1930. An epidemic of gastro-intestinal disorders broke out last October in Fond du Lac, Wisconsin. More than 1000 cases of dysentry among a total population of 28,000 were followed by 50 cases of typhoid, with 3 deaths. The water supply of the city is obtained from 7 wells, 5 located at the water works and 2 a short distance to the north, which range in depth from 480 to 1000 feet. The water is pumped by air lift to a storage reservoir, from which it enters the distribution system. The circumstances surrounding the outbreak, which began September 28, indicated contamination of the water supply. Chlorination equipment was installed on October 4. The wells at the water works are 200–600 feet from the Fond du Lac River, which receives the waste from a nearby tannery and the discharge from 2 small sewers. It was learned that on September 26 a new channel from the river had been opened near the tannery and approximately 800 feet from the wells. An old abandoned well was found in this channel. A cofferdam was immediately constructed around the point where the well was found, and a metal cylinder 4 feet in diameter by 6 feet high was driven into the ground around it. That this well was the source of the pollution was confirmed by placing a half ton of salt in the iron cylinder surrounding the casing and dissolving it with water from a hose. A second

half ton was applied 6 hours later. In less than 17 hours after the first application, the chloride content of the water in one of the wells increased from 60 to 126 p.p.m. and at the end of 18 hours it had increased to 263 p.p.m. After chloride of lime had been used to sterilize the casing of the old well, compressed air was applied under 80 pounds pressure, revealing a second abandoned well some 300 feet from the river channel. No evidence of seams in the channel were discovered. The well in the river was sealed with crushed rock and concrete. All the city water is now carefully chlorinated.—*R. E. Thompson.*

Why the Low-Water Stage at Cairo is Getting Lower. RAMEY WILLIAMS. Eng. News-Rec., **104**: 391–2, March 6, 1930. A graph is given of the low-water gage readings at Cairo, Ill., since the gage was established by the Weather Bureau in 1871, showing that the low-river stage has been gradually increasing since that date, and possible explanations are advanced.—*R. E. Thomspon.*

Pipe Lines of the Hetch Hetchy Aqueduct. M. M. O'SHAUGHNESSY. Eng. News-Rec., **104**: 405, March 6, 1930. The sections of the Hetch Hetchy aqueduct now completed comprise about 23 miles of 60- to 114-inch pipe. Nearly 50 miles of pipe have yet to be constructed to complete the initial installation. The completed sections consist wholly of riveted steel pipe, but it is expected that there will be keen rivalry among the makers of various types of steel and concrete pipe in connection with the construction of the remaining sections. Two submerged crossings, 2753 and 402 feet in length, both in salt water, were built of 42-inch cast iron pipe with barrel thickness of 2 inches, laid in 12-foot lengths. The longer of these reaches a maximum depth of 67 feet below mean sea level, and the maximum unbalanced pressure on either is 172 pounds per square inch. The joints, which are of the flexible ball-and-socket type, were poured with lead in the usual manner and calked by forcing in additional lead through tapped holes in the bells. The pipe was laid in a dredged trench, generally in clay bottom, and to prevent movement when under pressure a bed of crushed rock was placed in the trench and the trench was partially backfilled with crushed rock. Four 16- and 22-inch submerged steel lines parallel to the cast iron crossings, constructed in 1888 and 1900, have not shown any evidence of deterioration. These pipes were galvanized and coated with an asphaltic compound. They were laid on the bottom without trenching and are exposed for some distance from shore at low tide. The coating on the exposed sections appears to be in good condition, the leakage, if any, is negligible, and the resistance to flow does not appear to have increased materially. The Hetch Hetchy aqueduct pipes were coated with bituminous enamel, partially by dipping and partially by hand brushing over a thin priming coat. Careful handling is necessary to avoid damaging factory-applied coatings. Where the completed pipe is left exposed, a coat of aluminum paint over the external protective coating is desirable to reduce heat absorption when the pipe is empty.—*R. E. Thompson.*

Old-Country Practice in the Treatment of Hard and Contaminated Water. DAVID BROWNLIE. Cont. Rec. and Eng. Rev., **44**: 25–6, 1930. The recently completed 7-million-gallon per day Langford plant of the Southend Water

Works Co., England, is described. The raw water, derived from the rivers Chelmer, Ter, and Blackwater, has a total hardness of 330 p.p.m. (236 temporary and 94 permanent), contains the colon bacillus in 1 cc., and has an O_2 absorbed value of 2.35 p.p.m. (3 hrs., 37°C.). The water is stored in a reservoir of 60 million gallons capacity, from which it is pumped to the purification plant and from the equalizing reservoir in connection therewith 14 miles to the city. After 8 to 9 days' storage the water is treated with excess lime by the split method and with alumina coagulant, an excess of 2 grains of lime per gallon being maintained. The settled water is carbonated and passed through a battery of 14 Paterson rapid sand filters. The wash water is settled and returned to the raw water and the sludge from lime treatment is calcined in an oil-fired rotary kiln and re-used. The treated water has an average hardness of 100 p.p.m. and O_2 absorbed value of 0.60 p.p.m., and contains no *B. coli* in 100 cc.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Deep Gravel Wall Well is New Source of Brampton's Water Supply. Cont. Rec. and Eng. Rev., **44**: 138–9, February 5, 1930. A brief description of the gravel wall well recently constructed at Brampton, Ont. The deep well turbine pump showed an overall efficiency of 64.5 percent. The filters and chlorinator used in connection with the former supply, which was derived from wells and from Snell's Lake, are not required for the new supply, but are being held in reserve in case of emergency.—*R. E. Thompson.*

Forty Years of Research into Water Resources. F. H. NEWELL. Eng. News-Rec., **104**: 132–6, January 23, 1930. An interesting review and discussion of the history of stream gaging in the United States.—*R. E. Thompson.*

New Practices in Connection with Concrete. Developments of the Past Year. R. B. YOUNG. Cont. Rec. and Eng. Rev., **43**: 1495–7, 1929. A general discussion and review of progress in concrete engineering. As a result of studies, less emphasis is now being placed on the strength of concrete and more on its other properties, particularly its durability. The trend is toward insisting on washed and screened aggregates. Dirty materials are undesirable, but all very fine material in aggregate is not dirt in the sense that it is deleterious to concrete. The popularity of ready mixed concrete is increasing.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Kitchener's Water Works Activities. Cont. Rec. and Eng. Rev., **44**: 141–2, February 5, 1930. An outline of activities in connection with the water supply of Kitchener, Ont., during 1929. Consumption increased markedly during the year, exceeding the available supply of 3½ m.g.d. in September and October. A contract has been let for the construction of two additional wells.—*R. E. Thompson.*

The Colorado River—Economic Development of Its Basin. ELWOOD MEAD. Eng. News-Rec., **104**: 240–6, February 6, 1930. A rather extensive discussion of the conditions and controversies relative to the Colorado River which led to the adoption of the great Boulder dam project, which provides for the creation

of storage equivalent to the entire flow of the river for 1½ years. This will make possible the equalization of the flow in different years and the generation of a large amount of power.—*R. E. Thompson.*

Controlling the Colorado—Engineering Plans and Construction. RAYMOND F. WALTER. Eng. News-Rec., 104: 247–53, February 6, 1930. A detailed discussion of the Boulder dam project. The reservoir formed by the proposed dam will be more than 100 miles long and will be the largest artificial body of water in the world. The dam will be more than 700 feet high and will contain approximately 3,500,000 cubic yards of concrete, of which about 500,000 yards will be below low-water surface, the lowest point of the base being approximately 125 feet below low water. It will be a curved gravity structure, designed for maximum stress of 30 tons per square foot. The cost of the project, including power development and the All-American Canal, is estimated at $165,000,000.—*R. E. Thompson.*

Water Power Development in B. C. with Unusual Features. Cont. Rec. and Eng. Rev., 44: 52–6, January 15, 1930. A detailed description of the Ruskin hydro-electric plant of the British Columbia Electric Railway Co., under construction below the two existing plants on the Stave River. The water used is drawn from the tailwater of the Stave Falls plant, 3½ miles upstream, the available head being approximately 130 feet. The main dam is to be a concrete structure, gravity section, crest overflow type, 400 feet long on the crest, with a maximum height of 185 feet above foundation.—*R. E. Thompson.*

Break in Downstream Dike at Saluda Dam Releases Segregation Pool. Eng. News-Rec., 104: 374–6, February 27, 1930. On February 19, a 100-foot section of the downstream dike of the Saluda hydraulic-fill dam, under construction for the Lexington Water Supply Co., slumped or broke out, releasing the water in the segregation pool. The outflow washed out about 125,000 cubic yards of embankment on the downstream side, but carried out only about 1000 cubic yards of core material. Details are given of the accident. Only a slight interruption in the construction schedule will result.—*R. E. Thompson.*

State Denies Permission to Build San Gabriel Dam as Proposed. Eng. News-Rec., 103: 895–6, December 5, 1929. The application of the Los Angeles County Flood Control District for permission to build the San Gabriel dam was disapproved by State Engineer EDWARD HYATT on November 26, acting under authority of the new California dam control act. Refusal was based on an advance report made by a consulting board appointed by the state engineer to study the safety of the foundations of the proposed dam. As a "supplementary suggestion" the board found that an earth- and rock-fill dam of conservative design would provide a structure best suited to resist earth movement and could be built safely at the proposed site. Essential findings of the board are included.—*R. E. Thompson.*

Second Great Power Development on Saguenay River Begun at Chûte-à-Caron. Eng. News-Rec., 103: 889–95, December 5, 1929. A detailed descrip-

tion of project of Aluminum Company of America to develop the power possibilities of the Saguenay River between the tailwater level of the Isle of Maligne plant of the Quebec Development Co., and tidewater. Owing to the magnitude of the undertaking and the urgent demand for power, the development is being carried out in two stages. The first stage, the Chûte-à-Caron project, is to be brought into service in July, 1931, and the second, the Shipshaw project, at some later date. The Chûte-à-Caron project consists of a concrete dam 200 feet high across the river and a power house containing 4 hydroelectric units of 65,000 horse power each, developing 151 feet of the remaining head of 205 feet between the upper plant and tide-water.—*R. E. Thompson.*

Tests on Model Dam Determine Baffle Weir Design. C. E. Blee. Eng. News-Rec., 103: 931–3, December 12, 1929. The diversion dam to serve the initial stage of the hydroelectric development now being carried out on the Bridge River by the British Columbia Electric Railway Co. will be an overflow structure of rockfill timber crib construction. Ultimately a high rockfill dam will be built just downstream from the initial structure. A series of tests were made on a 1:12 model to determine the form of energy-dissipating device to be used for avoiding streambed erosion below the toe of the dam. The hydraulic jump appeared to be the most practical method. The crest of the dam will be 48 feet above the streambed and is designed to pass a maximum flood of 40,000 second-feet. The length of the spillway crest will be 650 feet, giving a crest depth in maximum flood of about 7 feet.—*R. E. Thompson.*

Design and Construction of Big Dalton Multiple-Arch Dam. E. C. Eaton. Eng. News-Rec., 103: 994–7, December 26, 1929. The Big Dalton dam, the eleventh unit of the flood-control and water-conservation program of the Los Angeles Flood Control District, was completed in August last. Features of this multiple-arch structure are the foundation problems encountered, which necessitated a change in design, and the weakened planes that were provided in the buttresses parallel to the line of principal stress to control the location of possible cracks. Although the dam has not yet been subjected to full load, temperature changes of from 30 to 100° have occurred without any evidence of cracking appearing in the members. A rockfill dam was first planned and work was started, a concrete toe wall having been constructed and a rock quarry opened, but lack of suitable rock at a reasonable price and unsatisfactory abutment conditions caused abandonment of the plans. Site was therefore moved 400 feet upstream and concrete structure adopted. The concrete toe wall will be used to provide a stilling pool for the spillway and pipe outlets. The dam has six arches supported by double wall buttresses, the highest one being 145 feet above streambed and 180 feet above lowest foundation. The buttresses are 60 feet center to center. The spillway was formed by discontinuing one of the side arches 8 feet below the top of the parapet wall and providing an outlet through a vertical reinforced-concrete tube 15 feet in diameter between two butresses. The stored water will be released gradually to replenish ground water storage, which has become seriously depleted owing to extensive pumping for irrigation.—*R. E. Thompson.*

Bull Run Concrete Not Too Dry or Too Wet. D. G. HENRY. Eng. News-Rec., 104: 296, February 13, 1930. Reply to criticism re concrete in Bull Run dam of Portland, Ore., water system. Dam has been subjected to spillway height pressure since May last. The drainage flow, which comes partly from foundation rock and largely through one contraction joint in which copper stop was damaged, amounted to 143 gallons per minute upon first filling of reservoir and has since diminished to 94 gallons. A small fraction of this, if any, comes through the horizontal construction joints. Only in one spot in the downstream slope has there been any percolation which was apparent, this being only sufficient to produce discoloration by moistening in cold weather.—*R. E. Thompson.*

Making Tight Joints in Concrete Pipe. EMERSON C. HALLOCK. Eng. News-Rec., 104: 36, January 2, 1930. Specifications for the construction of trunk sewers for the Westchester County Sanitary Commission, White Plains, N. Y., call for a test under 4-foot head of water. On one such job, where pre-cast vibrated concrete pipe was employed, the first step in making the joints was to place extra heavy bituminous sewer compound around the sleeve end of the pipe as it lay in the trench. A thick continuous strand of jute was then packed into this compound and the pipe placed in position and jacked home with screw jacks, which forced the compound and jute into the groove of the sleeve end. The jute was then calked inside and outside, more being added when required. Several days after laying a 1:2 mortar was placed around the inside of the joint and grout was poured around the outside, using a light packing of jute or burlap to hold the grout in position. After the grout had set the packing was removed and the remainder of the joint filled with 1:2 mortar. Tests were made on 400-foot lengths of 24- and 30-inch pipe laid in lengths of 4, 8, and 12 feet. The leakage was considerably less than 1 gallon per day per square foot of inside area for any 100-foot length.—*R. E. Thompson.*

Welded Joints Used in Long Oil Pipe Line. Eng. News-Rec., 103: 927, December 12, 1929. Brief details given of a steel oil pipe line recently completed between Cushing, Okla., and the Chicago district. Bell and spigot joints sealed by welding were used throughout the 624-mile length of the main section, which was 12 inches in diameter, and also in the 200 miles of 8- and 10-inch branch lines. The pipe sections were 40 feet in length. Each weld was made in 2 beads to eliminate pinholes. Current was supplied by portable gasoline-engine-driven welders drawn by horses or tractors. Despite the fact that welding was carried on during the winter and spring, the average number of welds per man per day on the 12-inch pipe was 10.3, with a maximum of 25 per day under favorable conditions. The line was tested to a pressure of 800 pounds per square inch. In one 334-mile section only 3 pinholes were found.—*R. E. Thompson.*

General Properties of Boiler Tubes with Special Reference on the Relation Between Corrosion and Fuel. M. KINUKAWA. J. Fuel Soc. Japan, 8: 649–63, 1929; Abstract sect. Ibid., 71–3. From Chem. Abst., 23: 4180, September 10, 1929. A lecture.—*R. E. Thompson.*

The Chemical Investigation of Trinidad Well Waters and Its Geological and Economical Significance. J. S. PARKER and C. A. P. SOUTHWELL. J. Inst. Petroleum Tech., 15: 138–82, 1929. From Chem. Abst., 23: 4171, September 10, 1929. Details of investigation of well waters in Trinidad oil fields. The chemical variations in the Trinidad waters are so small as to make it difficult to correlate them usefully with the geological data. Yet it is certain that differences between the upper and lower waters in a Trinidad structure can be established by chemical analysis, yielding information which will be a guide to the driller if, for instance, a water breaks into the well. Minor faulting in the structures contributes to the difficulty of understanding sub-surface conditions and interpreting the facts given by well water analysis. The iodine content is distinctive for certain fields. This element was determined by oxidizing the concentrated and acidified water with hydrogen peroxide, collecting the iodine in chloroform, and estimating it colorimetrically or by titration. Specific gravity, if taken uniformly at about 80°F., can be used to compute total solids. Three systems obtain for reporting results of analyses: the ionic system, in which the ions are reported as milligrams per liter; the combination system, in which the ions are combined hypothetically; and the PALMER system of combining the ions into "primary" and "secondary salinity" and "primary" and "secondary alkalinity" and plotting the 4 points as a small and characteristic graph for each water. In the PARKER system, percentages by weight of the several ions found are plotted upward additively from the base line and concentration in grams per liter horizontally. Each ion is thus represented as a rectangle. Alternate rectangles are blacked in. The order followed was CO_2, HCO_3, Cl_2, Na and Ca + Mg + SO_4; or if SO_4 was a large amount it was plotted separately, followed by Na and Ca + Mg.—*R. E. Thompson.*

The Subterranean Water Resources of Great Britain. EDGAR MORTON. Munic. Eng. Sanit. Record, 82: 600, 1928. From Chem. Abst., 23: 4284, September 10, 1929. A brief progress report is made on the mapping of water-bearing formations.—*R. E. Thompson.*

Observations on Ice. P. BALAVOINE. Mitt. Lebensm. Hyg., 20: 77–8, 1929. From Chem. Abst., 23: 4288, September 10, 1929. The cloudiness in the center of blocks of artificial ice is only partly due to the gas dissolved in water. It may also be caused by the mineral matter in hard water precipitating during freezing, as shown by the presence of a precipitate after melting, and by droplets of saturated solutions of these salts. When ice is to be analyzed, it should be melted in a closed vessel, as it tends to absorb ammonia from the air during melting. This fact may explain the presence of ammonia in cistern water obtained from melted snow.—*R. E. Thompson.*

River Pollution and Its Effects. J. H. COSTE. Munic. Eng. Sanit. Record, 82: 600, 1928. From Chem. Abst., 23: 4289, September 10, 1929. A brief discussion of the treatment and protection of the London, England, water supply.—*R. E. Thompson.*

The Destructive Action on Aqueous Bacterial Suspensions of Small Doses of Chlorine Introduced Under Violent Agitation and by Means of Metallic Powders. E. TECHOUEYRES. Rev. hyg. méd. prév., 51: 393–425 1929. From Chem. Abst., 23: 4286, September 10, 1929. As little as 0.1 mg. of chlorine added to 1 liter of river water and carefully mixed either destroys or profoundly alters such bacteria as *B. coli* and *B. typhosum*. This amount of chlorine could not be detected by taste. With *B. typhosum*, the chlorine acting for 1 hour on a suspension of 91,800 bacteria per liter destroyed 91.8 per cent. Complete sterilization required from 0.2 to 0.3 p.p.m. of chlorine. Thorough mixing was essential for best results. *B. coli* proved somewhat more resistant. Simple agitation of colon or typhoid bacilli in distilled water for 6 minutes reduced the numbers from 80 to 100 per cent. Metallic lead, tin, copper, zinc, brass, and bronze powders (0.01 gram per 100 cc. of distilled water) were added to *B. coli* suspensions. Although some sterilizing action was effected after several hours exposure, there was only slight immediate effect. Brass powder reduced an original count of *B. coli* of 185 (average) to 47 immediately after mixing; 211 to 5 after 3 hours; and 104 to 1 after 24 hours. When bacterial suspensions were filtered over beds of powdered metals, a considerable reduction was effected, the rate of destruction being, in general, proportional to the time of exposure.—*R. E. Thompson.*

How Lunéville Eliminated Typhoid Fever. DELORME. L'eau, 22: 51–4, 1929. From Chem. Abst., 23: 4288, September 10, 1929. Since the javellization of the city water supply from the River Meurthe was begun in 1914, the typhoid and paratyphoid have fallen from an annual average of 23 cases to less than 1 case per year.—*R. E. Thompson.*

Combating Boiler Corrosion. C. H. KOYL. Boiler Maker, 29: 164–5, 1929. From Chem. Abst., 23: 4287, September 10, 1929. Presence of sodium hydroxide in treated waters has nearly eliminated corrosion of all kinds. Use of soda ash on hard-water division between Perry and Council Bluffs, Iowa, has almost completely remedied pitting.—*R. E. Thompson.*

Swimming Pools—Their Design and Operation. C. A. NOVAK. Proc. Seventh Annual Water Works School, University of Kansas, Lawrence. This article emphasizes some of the important factors in making the pool attractive and useful. Shade for the spectators is desirable. Eighty-five per cent of the bathers use swimming pool areas between 5½ ft and 3 ft. depth. Wading pools for the small children should be securely fenced from the rest of the pool. A circular pool with deep water at the center is objectionable on account of the necessity for providing at center diving boards which interfere in swimming contests. Circular pools are also harder to guard. The usual rectangular pool with deep water at one end is considered less desirable than triangular or fan shape pools with deep water at one angle. Pools should be built to permit intercollegiate swimming races. It is estimated that only about 1 per cent of the total population visit a pool during the season and never all at the same time. A capacity equal to about 10 per cent of the expected daily peak load should be provided. Provision should be made for night use of the pools.

Circulation of the water with filtration and chlorination is essential. The return to the pool should be above the water not only for appearance but to provide aeration.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Some Examples of Pollution of Streams by Industrial Wastes. ROBERT SPURR WESTON. Jour. Boston Soc. Civil Engineers, 16: 6, 358, June, 1929. Some of the forms of polution are mentioned. Literature on the subject is listed and the question of legislation discussed. The Sudbury River in Massachusetts is taken as an example of a slightly polluted stream and the Pocasset River in Rhode Island as a grossly polluted stream due to wastes from textile establishments. The seasonal changes which the waters of these streams undergo are diagramed and discussed. Remedies are suggested. The author's conclusion states: The subject of industrial pollution is extremely important, not only for plants but for communities using the same streams. So far the data pertaining to the problem of purification of textile wastes are extremely limited, and it is hoped that increased appropirations may be placed in the hands of state authorities. Problems involving industrial sewage should be considered from the standpoint of the stream, and not from the standpoint of the individual plant. Group treatment is extremely desirable, and the formation of conservancy districts or river boards is to be recommended. Standards are difficult to establish, but it seems that an attempt should be made to maintain the dissolved oxygen at above 30 per cent, better above 50 per cent of saturation at all times.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

The Disposal of Oil-field Brines (A Preliminary Study). LUDWIG SCHMIDT AND JOHN M. DEVINE. Bur. Mines, Repts. of Investigations No. 2945, 17 pp. (1929). Chemical Abstracts, 23: 19, 4760, October 10, 1929. The successful use of ponds for evaporation in the district studied is limited to properties producing very small quantities of brine; however, ponds are of great value for temporary storage of brine. Plants for recovering the common salts from oil-field brines are uneconomical except in special cases. Further investigation of the brines produced with petroleum may disclose that the rarer salts can be economically obtained. The diversion of oil-field brines into selected streams offers possibilities. Detailed surveys covering all seasons of the year should be made of the various streams. A complete analysis to insure absence of poisonous salts should be made of all brines that are to be allowed to enter streams. The delivery of brine from a field to the selected stream can be accomplished by pipe lines, or small tributary streams, if available, could be set aside for that purpose, providing fresh H_2O can otherwise be supplied to those obtaining their H_2O for human or stock consumption from the tributary stream. The disposal of oil-field brines by returning them to a subsurface formation appears to be feasible in isolated instances. Great care must be used in attempting this method. Not only is there danger that the H_2O will migrate to fresh water sands and pollute a potable H_2O supply but also there is an ever present possibility that this H_2O may endanger present or future oil production. Also in Petroleum Times, 22,207–8 (1929).—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Cross Connections between Industrial and Public Water Supplies. E. SHERMAN CHASE. Jour. Industrial Hygiene, 11: 3, 85, March, 1929. No question exists as to the potential hazard to health resulting from the cross connection of polluted private industrial water supplies with public supplies. No valid reason exists for such connection in the great majority of cases. Under some conditions, however, the immediate abolition of cross connections with fire protection systems would result in an increased fire hazard to property and to the safety of mill employees out of proportion to the results to be gained. Under such special cases, the all-bronze, double check valve, properly installed, regularly and thoroughly inspected, tested, and overhaluled, affords as reasonably efficient a single mechanical safeguard, short of complete physical severance, as has yet been devised. Some risk of pollution remains as indicated by the results of tests cited. The development of the special fire pump chlorinator offers an additional safeguard, but experience with it has been too limited as yet to warrant the conclusion that the combination of double check valves and special chlorinator is equal to complete severance. Consequently, ultimate abolition of all cross connections, or its equivalent, between safe and unsafe supplies should be the goal. Pending such abolition, all cross connections except those with proper double checks, should be immediately severed.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

New York State Regulations for Swimming Pools. C. A. HOLMQUIST. Jour. American Association for Promoting Hygiene and Public Baths, 12: 36, September, 1929. The older swimming pools have been built and operated without due consideration to well defined standards and the question of public health has been given little or no consideration. These conditions are due, in a large part, to the lack of well defined standards or regulations. The Public Health Council of New York State on December 14, 1917, enacted sanitary regulations governing the construction and operation of swimming pools, which regulations have the force of law. Although these regulations were based on a report of the Joint Committee, the New York State regulations differ in a number of important features. The bacterial count and *B coli* standard are only one-fifth and one-tenth respectively, as stringent as those of the Joint Committee. It is believed that if adhered to these regulations will give more than reasonable protection to the health of bathers. When chlorine is used an excess of at least 0.2 p.p.m. must be maintained whenever the pool is in use. Distinction has been made between existing and new swimming pools. Regulations, however, covering such items as circulation of pool water, pre-pool showers, care of suits and towels, attendants, pollution of pools, and operating records are the same for both new and old. Experience has shown marked improvement in swimming pools since the passage of these regulations, and it is hoped that in a short time all swimming pools will meet the State Code requirements.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

The Use of Ozone for Bathing Places. F. E. HARTMAN. Jour. American Association for Promoting Hygiene and Public Baths, 12: 51, September, 1929. The present practice in sanitation of swimming pool water has fallen

into the habit of considering two phases, physical and biological. Although these two are important the control of organic matter is of equal importance. The ideal germicide is an oxidizing agent. The author lists various accomplishments with ozone for the purpose of eliminating all doubt as to its ability to accomplish the desired results. As little as 2 p.p.m. of ozone will decrease oxygen demand from 10 to 15 to no more than 0.5 p.p.m. Ozone in water in distinctly germicidal concentrations is in no way harmful or irritating to those swimming in it. The treatment of ozone and ultra-violet rays by the Joint Committee is such as to effectively close the door to these two methods of purification, by stating that the committee cannot recommend them.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Sterilization of Swimming Pools. VINCENT J. HARDER. Jour. American Association for Promoting Hygiene and Public Baths, 12: 27, September, 1929. Increasing popularity of swimming in North America is due to public health educational work, and the requiring of pool regulations to meet recognized standards of sanitation. The water is maintained clear and sparkling in most modern swimming pools with filters either of the pressure or gravity type, but this is not sufficient to assure health protection. Treatment for bacteria sterilization is absolutely essential. The pool is a place of contact, the water the transmitting medium, therefore, a sterilizing treatment applied to the pool water should carry its power of disinfection into the water of the pool. The answer to the best method of sterilizing swimming pool water is given in the section on disinfection in the report of the Joint Committee "from all available information the addition of chlorine, either as a gas or as a water solution by use of proper appurtenances, is today the most satisfactory method of pool disinfection." Standards for residual disinfection have been set as a minimum of 0.2 p.p.m. of excess chlorine; the maximum 0.5 p.p.m. By means of the orthotolodine colorimetric method, this test is very easy to make. The Committee have recommended copper sulphate for control of algae growths, but does not recommend this chemical for bacterial control.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Report of Investigation of Public Water Supply of Grand Forks, Grand Forks County, North Dakota. I. W. MENDELSOHN. Trans. 26th Annual Conference of State and Territorial Health Officers with the U. S. Public Health Service, St. Paul, Minnesota, June 8 and 9, 1928—Public Health Bulletin No. 191, 33. The water supply is taken from a nearby river, is coagulated with lime and alum, rapid sand filtered and chlorinated. Following a rather serious outbreak of dysentery among school children breaks were located in the river intake pipe. Sewage from nearby outlets entered the breaks placing a heavy load on the filters. The present investigation, among other things, showed many cross connections with river water supplies, a bypass around the treatment plant, improper location of the intake pipe, and a ventilator on the clear water basin allowing contamination to enter. Recommendations were made to correct these and for the city to proceed as planned with the issuing of bonds to reconstruct the entire system.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Incrustations on Wells and Their Chemical Removal. J. WIEGAND. Gas. u. Wasserfach, 72, 741–4 (1929). Chemical Abstracts, 23: 20, 4984, October 29, 1929. The brass or Cu screens on deep well pipes frequently become clogged with Cu sulfide formed by the H_2S contained in the water, nearly closing the mesh. Treatment with HCl by the method given removes this material and restores the efficiency of the well. Al is the only metal which can be used to coat the screen to prevent this action. Other causes of well failure are given.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Purification and Sterilization of Water by High Chlorination. RUDOLF ADLER. Gas. u. Wasserfach, 72, 675–8 (1929). Chemical Abstracts, 23: 20, 4985, October 20, 1929. Larger amounts of Cl than necessary to destroy bacteria will result in completely sterile water and the removal of organic Fe and Mn. The water should be filtered after chlorination. Excess Cl may then be removed by passing the water over active charcoal which converts the Cl to HCl. From time to time the charcoal must be washed with water containing Na_2CO_3 to remove original materials from the surface, after which the excess of Na_2CO_3 is destroyed by treating with $CaCl_2$, forming $CaCO_3$, which serves to neutralize the HCl formed from the free Cl. The C also removes phenols and the resulting water is very satisfactory.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Statistics on the Chemical Composition of the Water Supplies in Germany. (K. THUMM. Gas. u. Wasserfach, 1929, 72, 337). Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, 2: 10, A-329, August, 1929. Chemical analysis of drinking water from all the towns in Germany are being collected by the Landesanstalt, and arranged in tables, with the idea that they may prove useful to workers in connection with water supplies. The substances are calculated in milligrams per liter, the acids given as anhydrides and the bases as oxides. Copies of these collected statistics of the water supplies in Germany can be obtained from the Head Offices of the Deutscher Verein von Gas- und Wasserfach-Mannern e.V. (Berlin. W35, Lutzowstrasse 33/36).—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

On a Sudden Outbreak of Dysentery and Parathyroid A in Fushun, South Manchuria. Anon. Jour. Public Health Assn. of Japan, 5: 5, 8, May, 1929. Fushun, South Manchuria, is reputed to have more cases of infectious diseases than any other district on the South Manchurian Railway Zone, especially infectious diseases of the digestive organs. Even during the winter months dysentery patients have never ceased to appear, there being always ten or so patients every month. In February, 1928, some 100 cases of dysentery appeared and later over 100 paratyphoid A cases were found. Considerable data are given showing the time when these cases occurred, the geographical distribution, the age distribution and the racial distribution. This district is made up of Chinese, Japanese and Koreans. It was found that most of the patients had used unboiled water and had eaten vegetables from nearby suburbs. An investigation of the water works disclosed that filtration had been

suspended on account of repair. It was concluded that this outbreak was originally caused by the impure water, although infection no doubt spread from case to case on account of the unwholesome living conditions.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Kansas Water Ratings. JAMES L. BARRON. Proc. Seventh Annual Water Works School, University of Kansas, Lawrence, 106. Kansas water supplies are rated on the basis of the results of bacteriological examinations and the regularity with which samples are submitted. The percentages of good and excellent samples are multiplied by the number of samples received to give the comparative rating figures. The following definitions are given to define the classifications: Excellent, count at 37° below 100 per cubic centimeter and no positives; good, count at 37° over 100 per cubic centimeter and no positives; fair, positives in 1 or more 10 cc. portions; doubtful, positives in 1 or more cubic centimeter portions; bad, positives in 1 or more 0.10 cc. portions. This rating is applied to both ground water and treated surface water.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

A Serious Epidemic of Typhoid Fever. ANON. Missouri Public Health News, 1: 10, 159, June, 1929. "Few water-borne epidemics of typhoid fever have claimed as large a percentage of persons using a contaminated water supply as an epidemic now raging at Winston, Missouri." The consolidated school well is undoubtedly the source of the epidemic which had in perhaps two months amounted to 64 cases of the 178 pupils and teachers of the school. Water supply for the school is obtained from a tile lined well in which the static level is four feet below the floor of the basement. The sewer draining the toilets is about 7 feet above the level of the water in the well. Inspection of the well showed that there had been seepage into the basement from the sewer just outside. Fluorescein placed in the toilets appeared 72 hours later in the water. As soon as the cases were reported to the State Board of Health hasty measures were taken to check the epidemic.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Water Supplies of the Santa Fe Railway in Northern Arizona. G. L. DAVENPORT. Arizona State Board of Health, Bulletin No. 50, 33, July, 1929. An interesting and instructive paper on water supply conditions in northern Arizona in general, and on the problem confronting the Santa Fe Railway in providing a sufficient quantity of suitable water necessary for the operation of its trains in an extremely arid country.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Water Disinfection with Salts and Katadyn Silver (Krause's process). W. OLSZEWSKI. Z. angew. Chem., 1929, 42: 22, 625; Chem. Ztg., 1929, 53: 46, 451. Compounds of quicksilver and silver are strongly sterilizing, those of copper and zinc less so. KRAUSE showed that traces of metallic silver, in a form soluble in water, destroy bacteria. He ascribed this to an "oligodynamic," as distinct from the "chemical poison" effect of the metal salts. Copper sulphate has a stronger action than the chloride and silver sulphate

than the nitrate. By the commonly sold "Katadyn-Sterilizers" water is freed from suspended matter and complete extermination of *B. coli* is achieved; but ordinary water bacteria are more resistant. After a short time of working germicidal-activation of the water takes place, as is evident on mixing with untreated water. On the large scale, silver salts are too expensive and the costs with Katadyn silver are also rather high, though KRAUSE states that Katadyn filter material has a working life of five years. Rapid filtration through a Katadyn filter is not successful and large reservoirs are necessary so that the water may be subject to the desired activation before use. Author considers the process too uncertain for drinking water disinfection. In swimming pools with stirring and filtration of the water, possibilities of successful application are greater; but a daily fresh water addition is not to be avoided. Traces of dissolved silver would hardly affect the pollution introduced into the pool by the bathers, which necessitates abundant aëration. An experiment in Dresden to sterilize swimming pool water with Katadyn silver had to be discontinued because of insufficient flow through the filter, but further tests will be made.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

Residual Germicidal Action of Water Treated with Ultra-Violet Rays. E. C. BERNDT. J. Amer. Assoc. for Promoting Hygiene and Public Baths, 1927, 9: 36. Public Health Eng. Abst. U. S., January 14, 1928. E415a. Exposure of water to ultra-violet rays destroys bacterial life without adding odour, taste, or irritating qualities. Purification of swimming pool water by ultra-violet rays was found to give better results than periodic dilution with pure city water. Two turnovers of a pool water per 24 hours indicated a removal of 63 percent of the impurities, but the removal was found to be higher with ultra-violet ray treatment. The U. S. Bureau of Standards recently published a report on the germicidal action of ultra-violet radiation, in which they state that the killing of bacteria is not due to the small amounts of toxic chemical substances produced by the action of the rays.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

Typhoid Epidemic in Olean, N. Y. M. NICOLL. The American City, 1929, 40: 131. Epidemic broke out on September 10, 1928, and new cases occurred throughout October. All the facts proclaimed it waterborne. Outbreak of diarrhoea took place two or three weeks before the typhoid showing that pollution of the water occurred at end of August. Water supply of Olean is obtained from two sources, Olean Creek and the South Olean Wells. The surface water from the Creek, which receives surface drainage and the effluent from the Franklinville and Cuba sewage disposal works, is filtered and chlorinated before entering the distribution system. The records of daily tests of this water show no evidence of pollution during August or September. The South Olean well supply comes from one large open well standing back 60 feet from the river, at a level of 12 feet above the normal stage of the river, on the north side, and twelve 6- to 8-inch tubular wells, sunk on south side of the Allegheny river. Raw sewage from the south part of the city of Olean,

which has no treatment plant, is discharged into this river. It is possible for river water to enter the open well at high water, but there is no evidence of this having happened during September, 1928. The tubular wells, which are liable to pollution owing to their low position, were the seat of the contamination. The pumping of the water had been irregular throughout July, August, and September and finally on September 10th the suction pipe of one of the wells was found to be broken. The pollution was not detected at the time of its occurrence because the tests of the water after chlorination had only been made at infrequent intervals instead of daily, as recommended by the State Department of Health. The Water Commissioners of Olean are held responsible for the outbreak, because it was caused through their neglecting to keep proper control of the water supply. The State Commissioners of Health put forward recommendations for improving the Olean water supply by abandoning the South Olean well supply, constructing sewage treatment plants, etc.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

The Underground Water of the Rhine Valley in the Palatinate. G. J. LEHR. Städt. Tiefbau, 1927, 183; Wass. u. Abwass., 1928, 24, 199. The relations between the extent and the change in level of the underground water in the basins of the rivers Speyer and Rey and the rainfall and geological nature of the soil are discussed. The temperature of the water varies between 7° and 11°C. The water from the Durkheim well of 294 metres has a constant temperature of 19.5°; water from depths between 400 and 700 metres have temperatures from 29° to 35°. Water from the Bunter sandstone is soft, while that from the Tertiary and Quaternary beds has a hardness between 9° and 34° (170 and 600 p.p.m.). Chlorine content varies between 25 and 60 p.p.m and iron content is highest in water from the alluvium of the Rhine. Free carbon dioxide is generally less than 8 p.p.m., but rises to from 10 to 30 p.p.m. in water from the Bunter sandstone. Nitrate varies from 0 to 120 p.p.m. The water is generally free from bacteria.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

On Water Supplies (Especially Surface Water) in the United States of North America. C. REICHLE and R. WELDERT. Kl. Mitt. f. Wasser-, Boden-, u. Lufthyg., 1929, **5**: 5–7, 105. General account of information mainly collected during tour of inspection in the United States in 1925. Summary of the history of water supply plant, from installation of the first supply at Boston in 1652, is given. Leaving out of account some supplies of mixed or unknown origin, 64 per cent of present plants use underground water and 36 percent, surface water. Geological situation of many great cities renders only surface water available and in many cases this is obtained in a self-purified condition by drawing it from the Great Lakes or from reservoirs. In the case of river water, the increase of industry has made the purification problem a very difficult one. Filtration and chlorination methods are widely adopted and highly developed. The authors however observed that the formation of crusts in the upper layer of the filter sand was very common and they suggest remedies.

At first, especially in small places, supervisory bodies had to be appointed to enforce attention to the purity of the water; but these bodies later confined themselves mainly to advisory and educational work though they or some other body have in many cases the power to take direct action in cases of emergency such as the outbreak of disease. The water works companies, though not expected to guarantee a certain purity of water, can be sued for compensation in cases of illness or death which can be proved to arise from neglect of purification methods. The American water-works have developed under very special circumstances of enormous and rapid increase in industry and in the population of the great cities. The great available wealth of the country has played a part in this development, which is especially visible in the architecture and surroundings of the water works. An illustrated description of plants at nine cities and a short bibliography are given.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

Storage and Pumping Installation at Hengstey. O. SPETZLER. Wasserkraft u. Wasserwirtschaft, 1928, 22; Tech. Gemeindebl., 1929, 32: 11, 161. The large quantities of sludge in the Ruhr were found to be a serious trouble to water works and the Ruhr Federation decided to purify the river by damming it at Hengstey below the Lenne, using the dam also for the production of power. Above the purification station a storage reservoir was planned from which water could be led back to the Ruhr at times of peak demand. The size of the impounding reservoir is 4000 x 300–500 metres. Account is given of power plant and pumping plant for storage reservoir. The plant, which is now in operation, shows how self-purifying power of a river can be improved by damming. The Hagener water-works below Hengstey has already found the advantage of the new plant.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

The Water Supply of Leipzig. H. SCHILLING. Gesund. Ing., 1929, 52: 19 337 and 21, 377. History of the water supply of Leipzig, which was formerly obtained from draw-wells. In 1489 plans for a ground water supply brought by pipes were made and the scheme was carried out in 1500. Private enterprise provided the first wooden pumps supplied by wood or stone pipes. During the 16th century the number of wells increased rapidly and this form of supply continued until plans for a pressure supply were laid before the City Council in 1859. The Connewitz water works were built between 1863 and 1865 by the English engineers GRISELL and DOCWRA. Underground water was found to contain ferrous iron and the greater part of the supply was pumped from the Pleisz and was pure enough for use after being filtered through gravel filters. In 1881 it was found that further extension at Connewitz was impossible and new works were built at Naunhof, where a second plant was added in 1895. This supply is very pure, almost its only defect being the occasional presence of ferrous iron. By continued contact with air, this separates as ferric oxide and is removed by gravel filters. Water towers have been erected to distribute the ordinary supply to the high parts of the city. A special deep reservoir was also built for the North Leipzig high zone. In 1912 another supply works

was opened at Canitz where a ground water free from iron was found. There are now twelve city water works, delivering altogether some 20 million cubic metres per day. Article is illustrated with plans and pictures of the city and its water-works, old and new.—*M. H. Coblentz (Courtesy of the Department of Scientific and Undustrial Research, Water Pollution Research Board).*

An Investigation on the Influence of the Tides on the Underground Water Level. J. H. STEGGEWENTZ. Rapp. en Meded, v.h. Rijksbureau v. Drinkwatervoorziening. No. 9. May, 1929. Geo-hydrological investigations carried out in 1927, at site of new lock at Flushing revealed the existence of nearly impervious layers of clay and peat, between which the ground water is divided into several basins. Tides were found to occur in these basins, corresponding with those of the Western Scheldt, but with less change in head and with some time-lag. Pressure maxima in the basins were found to depend not only on the corresponding high tides in estuary, but also on other characteristics of the rising tide. Formulae have been worked out to express the relation existing between the water pressure in the basins and the rising tides in the river. The practical value of these formulae has been proved by means of the method of least squares. The head at any moment is influenced by the level of the rising tide, by that of the preceding low tide, by the maximum pressure of the artesian basin, and by the preceding minimum pressure; all of which are represented in the formulae. Similar formulae may be derived for the falling tides, if the characteristics of the falling and rising tides are clearly distinguished.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

Water for Tanneries. E. MEZEY. Collegium, 1929, **55**: 68. J. Soc. Chem. Indust., 1929, **48**: B 406. Titration curves have been determined for five different waters; (*a*) distilled, (*b*) river, (*c*) conduit, (*d*) well, and (*e*) water containing nitrogenous matter. Samples (*b*) to (*e*) were of waters used by tanneries, of which (*b*) and (*c*) contained only 5° (90 p.p.m.) of hardness, respectively. The suitability of a water for tannery purposes can be judged from its buffering effect, as shown by these titration curves. The flatter the curves, the greater is the buffering effect. The greatest buffering effect was shown by sample (*e*).—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

The Hydrology and the Physical, Chemical, and Bacteriological Properties of the Water in the Loire Valley. M. F. DIÉNERT. Annales des Services Techniques d'Hygiène. Gauthier-Villars et Cie., Paris, 1927. Report of research work carried out by the "Services Techniques d'Hygiène" of Paris on the hydrology and the composition of the underground and surface water in the Loire Valley, which is one of the most important sources of the Paris water supply, during the years 1920, 1921 and 1926. Wells are sunk in the valley at varying distances from the river and water is obtained by pumping. The final aim of the investigations is to discover the best positions in the valley from which to obtain an abundant supply of pure cool water throughout the year. The report contains tables of results of both chemical and physical

analysis of the waters from the separate wells examined in 1920 and 1921 and also results of *B. coli* tests. Sketch maps are given, showing position of the wells and changes in the bed of the Loire during the investigations. Geological sections of the strata in the alluvium, tables of changes in water level in the wells during 1920; graphs of the variation in temperature of the river and well water during 1926 are also appended.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

An Investigation of the Chemical Composition of the Reservoir Lake in the Wäggital. L. MINDER. IV Congresso Internazionale di limnologia teorica ed applicata. Settembre 1927. Societa Tipografica. A. Manuzio. Rome. 1928. The lake in the Wäggital was dammed for a reservoir in 1924, and the raising of the water level dislodged quantities of turf and soil, which first floated on the surface of the lake and was later precipitated. In 1925, an analysis of the lake waters showed a division into an upper oligotrophic layer and a deeper extremely eutrophic layer, owing to the decomposition of large quantities of organic matter. The deeper lake waters were found to contain no oxygen, but an excess of carbon dioxide, hydrogen sulphide, ammonia, and ferrous bicarbonate and to have a hardness twice as great as the surface waters. By 1926, however, the composition of the water was the same throughout the depth of the lake, and showed a normal, slightly eutrophic character. The conditions in the lake were reproduced in the laboratory by artificially polluting samples of water containing no oxygen with quantities of nutrient gelatine, varying from 0.5 to 5 cc. per 1.5 litre and a small quantity of ferric oxide and leaving them to stand in the dark. The effect of the decomposition of the organic matter on the composition of the water showed three phases of change. In the first phase, which appears in slightly polluted waters, such as underground waters, the iron passes into solution, but is precipitated again on exposure to the air, while in the second phase the effects are similar except that hydrogen sulphide can be detected. This second phase was observed in the deep waters of the Wäggital lake. In the third phase which in nature is reached only in the sludge from the floor of eutrophic lakes, the iron is precipitated as sulphide by the hydrogen sulphide in presence of excess of ammonia and the precipitate gives the water a greenish black to black colour.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

Tinned Copper Water Pipe. A. MASSINK. Verslagen en Mededeelingen betr. de Volksgezondheid, 1930: 7, 1069–1080; Appendix 1 to Annual Report of Government (Holland) Water Supply Bureau for 1929. Corrodibility of copper by water under various conditions is discussed. Protective coating will sometimes be advisable, if not imperative. Advantages of tin for this purpose are preëminent, it being hardly susceptible to attack by water. Protection afforded by tin coating will depend upon (*a*) its continuity; (*b*) its thickness; and (*c*) its purity. Practical laboratory tests for determining these properties are described and results obtained in practice are quoted. Specifications provisionally proposed are: (*a*) practical freedom from pores; not more than 0.5 mgm. of copper may be dissolved by standard ammoniacal solution of am-

monium persulphate under standard test conditions per 100 square centimeters of varnish-free exposed surface; (*b*) thickness; not less than 15 grams of tin must be applied per square meter of surface (corresponding to coating thickness of approximately 0.002 mm.); (*c*) purity; lead content of tin coating must not exceed 0.5 percent. Provisional nature of these specifications is stressed, pending accumulation of further data from practice. Especially is this the case respecting thickness; heavier coatings may be found necessary.—*Frank Hannan.*

Galvanized Iron Pipe for Water Supplies. Ir. J. DE GRAAF. Verslagen en Mededeelingen betr. de Volksgezondheid, 1930: 7, 1081–1088; Appendix 2 to Annual Report of Government (Holland) Water Supply Bureau for 1929. Explains theory of protection by zinc coatings and reasons for failure. Continuity of coating is its first essential; thickness, its second; and purity, its third. Hot-dip and electrolytic methods of manufacture and their respective advantages and disadvantages are compared, conclusion being in favor of properly carried out hot-dip galvanizing. PREECE test is rejected. For detecting discontinuities, 10 percent gelatin solution containing 1 percent potassium ferricyanide is recommended. Thickness is best determined by measurement of hydrogen liberated when antimoniated hydrochloric acid is allowed to act upon a definite area, iron being only negligibly attacked by this reagent under test conditions. Method of performing this test is fully described and illustrated. Protection by zinc coating can be permanent only against waters non-aggressive with respect to calcium carbonate. Aggressive waters must, sooner or later, eat through the zinc to the iron. Illustrations are given showing this progressive attack. It is proposed that specifications for good galvanized iron pipe for water supplies should include; (1) not less than 600 grams zinc to be applied per square meter of surface; (2) lead content of zinc not to exceed one-half of one percent; (3) coating must be free from pores.—*Frank Hannan.*

The Public Always Pays. Monthly Bulletin, Indiana State Board of Health, 33: 5, 73, May, 1903. The Common Council of city of Fort Wayne recently made appropriation of $65,000 to pay city's share of cost of outbreak of typhoid fever which occurred in Fort Wayne in 1923. Pennsylvania Railroad Co. is paying an equal sum for that company's share of cost. Outbreak was traced definitely to physical cross-connection between industrial water supply of the railroad shops, taken from St. Mary's River, and public water supply of city.—*G. C. Houser.*

New Water Supply System. Monthly Bulletin, Indiana State Board of Health, 33: 5, 76, May, 1930. In April new filter plant and water supply of Farm Colony for Feeble-Minded, near Butlerville, Ind. went into operation. Water supply is obtained from Muskatatuck River, and is treated by aëration, coagulation, sedimentation, filtration, and chlorination. Capacity at normal rate of operation is 432,000 gallons per day. Clear well and elevated tank, with combined capacity in excess of 200,000 gallons, provide ample storage facilities.—*G. C. Houser.*

The Work of the Pennsylvania State Health Department. T. B. APPEL. Pennsylvania's Health, 8: 3, 4, May–June, 1930. Bureau of Engineering is one of largest and most responsible in the Department and is largest state sanitary engineering bureau in the country. It is charged with care of domestic and municipal water supplies of state. All nuisances reported by complainants, or discovered by agents of the bureau, are investigated and, where possible, abated. In close connection with this bureau is Sanitary Water Board, concerned with conservation and purification of streams. The board as part of its functions supervises all public and municipal sewerage projects.—*G. C. Houser.*

Engineers Play Detective. Pennsylvania's Health, 8: 3, 26, May–June, 1930. The bureau of engineering recently discovered cause of obnoxious taste in water served to Wilkinsburg and other Pittsburgh environs. Drinking water is secured from Allegheny River. Exhaustive investigation resulted in discovery that a freight car containing coal-tar oil had been wrecked along a tributary of the Allegheny in early part of year. Part of contents was spilled from car and remainder had been dumped on a cinder fill between railroad tracks and stream. Thaw following cold weather loosened the oil, which was washed into river by rain and passed down stream on the high water to intake of water company.—*G. C. Houser.*

Attorney-General Renders Opinion on Unsafe Water Supplies. Health News (New York State Department of Health), 7: 23, 89, June 9, 1930. Attorney-General WARD believes that posting of notices to effect that water is unfit for drinking purposes does not absolve a municipality, or water company, from using diligent effort to render said water pure and wholesome, and that if a water company, or municipality, should fail so to do, the water company, or municipality, is liable in damages to a person injured by reason thereof, and that mere posting of such notices will not relieve such company, or municipality, from its liability.—*G. C. Houser.*

Committee on State Waterways Pollution Submits Recommendations. Health News (New York State Department of Health), 7: 26, 103, June 30, 1930. Following recommendations have been submitted by special committee to Medical Society of State of New York: (1) that the society approve of plan of State Department of Health to secure for all municipalities supplies of water from sources other than rivers; (2) that the society commend activities of the department aiming to secure universal treatment for all sewage deposited in rivers; and (3) that the society secure as far as is possible support of the principles (*a*) no river water for domestic purposes; and (*b*) no untreated sewage for the Mohawk and Hudson Rivers.—*G. C. Houser.*

Stream Improvement Activities of the State Board of Health. Monthly Bulletin, Indiana State Board of Health, 33: 6, 86, June, 1930. The past several years have seen marked activity on part of Board in investigation and improvement of condition of streams throughout Indiana. In point of magnitude, investigation of White River from Muncie to Spencer comes first.

In this case samples of water from river and tributaries were collected at regular intervals for more than a year. Problem of disposal of industrial wastes has received close attention. Most serious pollution has resulted from phenolic wastes from by-product coke plants and wastes from canneries, paper mills, and dairy product industries. As result of activities of Board, about $1,500,000 has been spent for phenolic waste treatment works by two steel plants in Calumet region.—*G. C. Houser.*

Lick Creek Stream Pollution. Monthly Bulletin, Indiana State Board of Health, 33: 6, 93, June, 1930. On May 31, 1930, Department of Sanitary Engineering issued report of investigation of pollution of Lick Creek in Blackford County, Indiana. Conclusions are that the pollution, caused by domestic and industrial wastes from Hartford City, is responsible for health and property nuisances throughout length of stream, is prejudicial to free use of stream for agricultural purposes, and is in violation of property rights of downstream riparian owners. Report recommends that Hartford City proceed without undue delay to abate these conditions by constructing necessary intercepting sewers and sewage treatment works.—*G. C. Houser.*

New School Buildings. E. L. Filby. Florida Health Notes, 22: 6, 93, June, 1930. Early in 1930, Florida State Board of Health passed regulation requiring submission of plans of school buildings to board for approval before contract for construction is let. School buildings now being erected must have water supply taken from safe source and handled correctly. If a city supply is available, it will, of course, be used. If there is no water supply nearby, a well must be driven or drilled and pump installed. Many Florida waters are high in hydrogen sulphide, and, unless this is aërated out, excessive corrosion of pipes and fixtures may take place. Hence, before water supply well is accepted, it should be checked for H_2S and also for iron.—*G. C. Houser.*

An Engineering Report. Pennsylvania's Health, 8: 4, 29, July–August, 1930. According to 1929 report of bureau of engineering, recently submitted to Secretary of Health, there are now 197 filtration plants in Pennsylvania serving 6,000,000 people. In 1889 there was but one filtration plant, serving 600 people and located at New Bethlehem, Clarion County. Nine new filter plants were installed in 1929, serving 30,000 additional people. Present total water filtration capacity of Pennsylvania amounts to one billion gallons per day. Chlorination is used in 310 water works, serving more than 2,000,000 people, with daily capacity of 281 m.g.—*G. C. Houser.*

The Drought. J. C. Matthews. Monthly Bulletin, Indiana State Board of Health, 33: 8, 122, August, 1930. During early part of August, Department of Sanitary Engineering of Indiana Board of Health investigated water supply conditions in counties bordering Ohio River. Aside from economic conditions caused by the extended drought, problem of obtaining water for domestic and stock purposes was quite serious. Various county highway departments, cities, and U. S. Quartermaster Depot at Jeffersonville had most of their water carrying equipment in this service. Shallow dug wells, springs, abandoned

quarries, and streams were used as auxiliary supplies. Although water used for stock was not treated, practically everyone followed instructions for treatment of drinking water.—*G. C. Houser.*

Water Supplies in Southern Indiana. Monthly Bulletin, Indiana State Board of Health, 33: 8, 127, August, 1930. Southern Indiana, by virtue of its topography, is not adapted to industries other than agriculture, quarrying, and mining. Even in some of larger communities, water supply is taken from dug wells, or cisterns, improperly constructed and located, and privately owned. In nine of larger towns having public water supply systems, a total of 11,000 people are furnished with untreated surface, or spring, water which has been declared unsatisfactory and unsafe for human consumption.—*G. C. Houser.*

Inspectors' Problems. Public Health News (New Jersey State Department of Health), 15: 9, 213, August–September, 1930. Discusses a few camp water supply problems submitted to Department's inspectors by puzzled camp directors. In one case, sample of water from dug well, far from any possible source of serious contamination, gave a good chemical analysis; but bacteria of coli-aërogenes group were present to extent of 10 in 1 cc. The solution was that a new concrete slab cover had been built over well and a lot of dirt had been knocked into the water. Pumping and time for settling was the cure. Contamination of dug wells at two camps appeared to be due to splash and waste water from pumps, which were located on the well covers. Suggested remedy was to put pump on a platform 10 to 20 feet away from well and lead a pipe horizontally from pump to well.—*G. C. Houser.*

Four Communities Make Sanitary Improvements. Health News (New York State Department of Health), 8: 36, 144, September 8, 1930. Plans and specifications for modern water purification plant are now being prepared for Gouverneur, N. Y. Site has recently been selected for new well supply for Norwood, N. Y. Oakfield, N. Y., has recently acquired additional source of water supply and installed purification plant, providing for filtration and chlorination. Dunkirk, N. Y., has practically completed construction of new sewage disposal plant.—*G. C. Houser.*

The Man In The Case. Illinois Health Messenger, 2: 18, 165, September 15, 1930. The drought is taking the blame for 25 percent increase in typhoid fever over last year's prevalence. Doubtless it is an important factor. Water cannot be contaminated with typhoid germs, however, unless some person supplies the germs. Where public sewage disposal is concerned, installation of adequate and efficient sewage treatment plants will solve the problem. When degree of pollution of a water supply increases, it is important to modify the sterilizing facilities to insure potable supply. If all excreta of typhoid patients were sterilized, danger of contaminating streams with disease germs would be greatly reduced.—*G. C. Houser.*

The Work of the Sanitary Water Board. T. B. APPEL. Pennsylvania's Health, **8**: 5, 4, September–October, 1930. This administrative Board in Pennsylvania Department of Health has jurisdiction over sewerage and over pollution of waters of state. It formulates policies, initiates projects, and acts upon recommendations of its engineers relative to investigations. Policies are (1) to classify the waters of state in accordance with their present and probable future use and condition; (2) to improve present condition of these streams where suitable methods are known; and (3) to investigate and devise reasonable and practical methods for treatment of those wastes seriously affecting Pennsylvania's waters for which there is now known no satisfactory method of treatment.—*G. C. Houser.*

Campaign Started against Pollution of Interstate Waters. Health News (New York State Department of Health), **7**: 40, 158, October 6, 1930. Program for nation-wide campaign against pollution of waterways was initiated at second Tri-State Conference for Purification of Waterways which met recently at New York. To prevent pollution of interstate waters is objective of this movement. Draft of bill has been prepared for introduction in legislature of New York, New Jersey, and Connecticut at coming sessions. In addition, committee has been named to prepare and introduce in Congress an amendment to present law, to include sewage among prohibited forms of pollution and to empower United States attorneys to prosecute parties who allow such pollution to enter interstate waterways.—*G. C. Houser.*

The Use of Barium Aluminate in Water Softening. ANTONY SETON. Eng. & Boiler House Rev., **44**: 54–6, 1930. Previous work (C. A., **24**: 1687) has shown value of barium aluminate for H_2O softening in that precipitation of SO_4 as well as of Ca and Mg is accomplished by it. Chemistry of these reactions is indicated and suggestion made that it may sometimes with advantage replace Na aluminate. Commercial Ba aluminate can be obtained in form of powder which is from 38 to 40 percent water soluble. This has approximate composition $11BaO.\ 8Al_2O_3$. Laboratory studies indicate that from 1.5 to 2 times theoretical amount of aluminate is needed for precipitation of $CaSO_4$, $(CaHCO_3)_2$, $MgSO_4$, and $MgCl_2$, which is from 80 to 95 percent complete. Mixtures of $Ca(HCO_2)_2$ and $CaSO_4$ were precipitated by the amount necessary for the HCO_3 alone, thereby reducing dosage required in practical water softening to theoretical amount. With mixtures of Mg salts 75 percent of theoretical amount was found adequate. Study is to be continued under industrial conditions.—*Edward S. Hopkins* (*Courtesy Chem. Abst.*).

Epidemic of Proteus Infection Coincident with that Organism in Water Supply. K. BECKMANN and R. HURTHLE. Deut. Med. Woch., 1929, **55**: 1628–9. From Bull. Hyg., **5**: 2, 134, February 1930. In Greifswald, *Proteus vulgaris* found in the water supply in 1928 was associated with an epidemic of approximately 100 cases of gastro-enteritis, diagnosis resting upon isolation of *Proteus vulgaris* from stools in every case tested and in one instance from urine. No typhoid or paratyphoid bacilli were found in this way. One strain of *Proteus* was obtained from the water and from one patient while another

(human *Proteus*) was isolated from fifty percent of the patients, but not from the water. It is concluded that the human passage modified the character of the *Proteus* strain.—*Arthur P. Miller.*

Water Fever; a New Epidemic Disease in the Moscow District. W. A. BASCHENIN. Zent. f. Bakt. I. Abt. Orig., 1929, 113: 438–47; **Haematology of "Water Fever."** A. P. MURATOWA and N. A. JABLOKOFF. Ibid., 447–50. **Water Fever Epidemic in the Moscow District in the Summer of 1928.** W. A. BASCHENIN. Ibid. 450–452; From Bull. Hyg., 5: 2, 158, February, 1930. An epidemic in flooded districts of Russia appeared to be identical with those observed in Silesia in 1891 and in Bavaria in 1926. This recent (1927) epidemic was in one district diagnosed as paratyphoid and in another as influenza. Only one out of 411 cases proved fatal. BASCHENIN suggests that further investigators look for spirochaetes and streptococci. In a further paper he comments on undesirability of terms "marsh fever" and "mud fever" and comments also upon fresh epidemic occurring in 1928 in which number of cases was 200. Epidemiological circumstances and clinical features were the same as those in 1927. All the patients were peasants who had been working up to their hips in water. Cultivation of the urine yielded streptococci in 5 out of 8 cases. BASCHENIN concludes that there is no justification for regarding water fever and infective jaundice as the same.—*Arthur P. Miller.*

The 1926 Epidemic of Enteric in Rostow on the Don. S. B. DUBROWINSKI. Zent. f. Bakt. I. Abt. Orig., 1929, 113: 224–44. From Bull. Hyg., 5: 1, 49, January, 1930. Epidemic was preceded by outbreak of gastro-enteritis embracing about 40,000 cases. Enteric epidemic commenced towards end of April, increased to first week of May and declined rapidly towards end of second week; but it was not until end of year that it ceased. Cause was found to be fecal contamination of the water supply, due to crack in a water pipe. Mortality was higher in males than in females, especially between ages of 16 and 25, whereas between 26 and 35, reverse held good, probably due to antityphoid inoculation.—*Arthur P. Miller.*

Intestinal Bacteria of Colon Type in Birds in Relation to Water Supply. I. E. MINKEWITSCH. Ztschr. f. Hyg. u. Infektionskr., 1929, 110: 502–512. From Bull. Hyg., 5: 3, 207–8, March, 1930. Character of normal intestinal flora of wild and domesticated birds has sometimes practical importance in connection with contamination of water supplies. Author describes his experimental work in determining the bacteria excreted by various fowls. He concludes that presence or absence of *B. coli* in intestinal tracts of birds depends generally on their feeding habits.—*Arthur P. Miller.*

Physical Characteristics of Water: Freshness, Odour, Taste and their Correction. A. GUILLERD. Ann. d'Hyg. Pub. Indust. et Sociale, 1929, 7: 445–89; 509–25. From Bull. Hyg. 5: 4, 290–291, April 1930. Sulphur odors (H_2S and COS) are readily removed from water, but odours due to oils produced by algae are less easily dealt with. Intensity of taste is difficult to define; writer suggests under the name "olfacty," explanation of which is given, a quantitative

measure of this property. The individual sense of taste varies so much that it is difficult to discuss it. A water which has taste to a stranger may be inoffensive in that respect to local persons constantly using it.—*Arthur P. Miller.*

River Pollution: with Special Reference to Securing Steps Which Can Be Taken for Its Prevention. H. M. WILSON. Brit. M. J., 1929, 997–9, November 30, 1929. From Bull. Hyg., 5: 4, 292, April, 1930. In England, position with reference to condition of rivers is much better than 40 or 50 years ago. This is particularly true in areas where rivers boards are functioning. Strengthening the law seems to have less bearing on improving conditions than establishment of properly functioning rivers boards. Writer suggests that further improvement will be accomplished only by appointment of more of such boards. Useful changes in the law are suggested, which would enable rivers boards to deal with cases where question of taking wastes into a public sewer arises, and to overcome jealousies between various local authorities which lead to construction of a number of small plants where one central plant would be more efficient.—*Arthur P. Miller.*

Thirty Years' Work of the Paris Water Examination Service. M. DIÉNERT. Ann. d'Hyg. Pub., Indust. et Sociale, 1929, 7: 608–21. From Bull. of Hyg., 5: 4, 292–293, April, 1930. Having studied the sources of raw water for Paris, attention was directed to the elimination of points at which water might leak into aqueducts and reservoirs. Measures were taken to exclude rain water from the roofs of reservoirs. Newly laid pipes were cleaned and sterilized and when sediment was discovered in pipes through the flushing of fire hydrants, the pipes were cleaned out by an organization created to deal with them. The use of fluorescein has become unreliable since the purified river water is itself somewhat fluorescent. The washing of fruits and vegetables in the market with industrial water has been eliminated, pure water being supplied for that purpose. Parisians were prejudiced against chemically treated water, but in the early days of such treatment no taste trouble was experienced. That which developed later was eliminated by using a substitute for tar at pipe joints and by treating the water at reservoir with permanganate.—*Arthur P. Miller.*

Water Supplies of Coastal Towns in Ceylon. S. MAHADEVA. J. Inst. San. Engineers, 1929, 33: 101–30. From Bull. Hyg., 5: 4, 293, April, 1930. Colombo, the capital of Ceylon, obtains its water from a reservoir thirty miles from town. Until 1915, only treatment it received was straining through fine fire screens. Now rapid filters of Jewell type with capacity of 12 m.g.d. are in use. Some few other towns are served with a limited supply of piped water, usually taken from an interconnected system of shallow wells. Some measures are taken to protect gathering grounds, but in most places the supply comes from private wells and pollution is common.—*Arthur P. Miller.*

Evaporation of Water for Mineral Analysis. P. BRETEAU. Bull. Acad. Med., 1929, 102: 216–18. From Bull. Hyg., 5: 4, 294, April, 1930. Addition of hydrochloric acid to make water slightly acid before concentrating by evaporation is not satisfactory when such metals as antimony, bismuth, and

zinc have to be sought for. The chlorides of these metals are too volatile. When evaporating water containing nitrate in a platinum basin, urea might be added to eliminate nitric acid and prevent the solution of platinum. It is better to have water feebly alkaline for evaporation when seeking antimony, copper, and zinc.—*Arthur P. Miller.*

Hygiene of Public Swimming Baths. A. L. THOMSON. Canadian Engineer, 1928, **55**: 721–2. From Bull. Hyg., **5**: 4, 295, April, 1930. Cleanly habits on part of bathers in swimming pools must be insisted upon. It is advisable to eliminate use of inferior bathing suits which stain the water with dye and introduce fluff. Comparison of sterilizers for use in swimming pools is made.—*Arthur P. Miller.*

Disinfection of Swimming Baths in the Tropics with Chlorine and Chloramine. K. HOLWERDA. Meded. Dienst d. Volksgezondheid in Nederl.-Indie, 1928, **17**: 357–8. From Bull. of Hyg., **5**: 4, 295, April, 1930. Chloramine has slower germicidal action than hypochlorite chlorine, but is, because less readily acted upon by light (in an open pool), preferable to chlorine, or to hypochlorite. It is also unobjectionable in concentrations up to 2 p.p.m., a great advantage when large dosage is necessary. The simplest way to apply chloramine is to add ammonia, or ammonium chloride, to the chlorinated water. Chloramine and hypochlorite should not be used at the same time. Such procedure leads to great loss of active chlorine.—*Arthur P. Miller.*

The Relation of Ear Conditions to Bathing. W. I. DAGGETT and R. COVE-SMITH. Brit. Med. Jour., 1929, August 17, 296–7. From Bull. Hyg., **5**: 4, 296, April, 1930. Inflammations of the ear flare up with every swimming season. Patients can be grouped as (1) those previously healthy, (2) those having septic nasal conditions, (3) those with perforations, and (4) those subject to recurrent dermatitis, or furunculosis, of the external meatus. It is the authors' opinion that acute otitis media from swimming occurs only from public swimming pools and not from sea or river bathing. Correct breathing is essential to eliminate rush of water into nasal passages, and exclusion from swimming pools of all persons with septic nasal conditions, or perforations, would be desirable.—*Arthur P. Miller.*

Sinusitis and Otitis in Swimmers. G. C. SAUNDERS. Amer. J. Hyg., 1929, **10**: 253–60. From Bull. Hyg., **5**: 4, 296, April, 1930. Among swimmers, beginners, expert divers, and polo players are those most frequently affected with nasal and aural infections. Questionnaire covering probably 10,000 swimmers indicated that sinusitis and otitis occurred in those doing plain swimming up to 25 per cent and among divers, plungers, and polo players up to 50 per cent. Writer discusses use of rubber plugs to protect the ears and nostrils of divers and of a metal clamp to close the nostrils when diving. Correct habits of breathing among beginners is important.—*Arthur P. Miller.*

Estimation of Urea. Its Decomposition by Bacteria and by Chlorine. Chlorination of Swimming Bath Water. H. WETTE. Arch. f. Hyg. u. Bakt., 1929,

101: 222–33. From Bull. Hyg., 5: 4, 296, April, 1930. Pool water becomes polluted with urine and it is desirable to be able to estimate degree of this pollution. Since urine contains urea, latter would seem to be suitable substance to use as criterion. Author has worked out method of estimation based on conversion of urea into ammonium carbonate by means of urease.—*Arthur P. Miller.*

NEW BOOKS

Town Water Supplies. P. LHEUREUX. Review in Bull. Soc. Ing. Civ. de France, 1928, 81: 1299. This book deals with the means of solving the present urgent problem of supplying growing towns with sufficient quantities of pure water. The first part enumerates the requirements of modern towns, and the second part, under the title of "Resources en Eau," studies the means of satisfying these needs. Methods for studying the existence, position and quality of underground water are explained. The different forms of works for obtaining ground and surface water, their dimensions and details of construction and operation, the means of protecting supplies from pollution, and the various processes of purification are treated in full. The author cites many concrete examples and calculations drawn from his own work. The legislation in relation to all matters dealing with water supplies is summarised in an appendix.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

Quality of Water of the Colorado River in 1926–1928. C. S. HOWARD. U. S. Geol. Survey, Water Supply Paper 636-A, 14 pp. (1929); cf. COLLINS and HOWARD, C.A. 21, 2947; 23, 458. Chemical Abstracts, 23: 22, 5520, November 20, 1929. Analyses are given of the water collected at different gaging stations. During 1926–27 (October 1, 1926, to September 30, 1927) the average load of dissolved material amounted to 36,600 tons per day at Grand Canyon, 37,400 tons at Topock and 39,100 tons at Yuma, Arizona. For 1927–28 (October 1, 1927, to September 30, 1928) the respective values were 29,400 at Grand Canyon and 26,200 at Yuma. The mean total hardness was 285 p.p.m. in 1926–27 and 254 p.p.m. in 1927–28, as compared with 251 p.p.m. in 1925–26.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

The Water Purification System of Helsingfors. SKOG, ALBIN. Tekniska Foreningens i Finland Forhandlingar, 50: 177–181, 1930. Purification system is based on coagulation with aluminum sulfate, followed by rapid sand filters, eight of which, of Jewell type, with total area of 21 square meters, are used. Sand depth is 105 cm. and grain size, 0.5 mm. It is supported by 20 cm. layer of gravel. Filters are washed once per 24 hours for from 10 to 15 minutes. Hardness has been kept at about 2.0°, German scale, or 36 p.p.m., particularly since electricity has supplanted steam as power for industrial purposes. Optimum alum requirements are from 55 to 100 grams of 17 per cent Al_2O_3 material per cubic meter. In summer settling period of from 2.3 to 2.9 hours is required and in winter, of from 4.5 to 5.7 hours. An additional two hours settling period is required to reduce the bacterial count. Settling takes place

in three basins in series which are cleaned once a month. Liquid chlorine has been used since 1928. Chlorophenol tastes occasionally cause trouble; their origin has not yet been determined.—*H. C. Duus.*

Water Supply and Utilization. By DONALD M. BAKER and HAROLD CONKLING. Published, 1930. John Wiley & Sons, Inc. This volume constitutes an outline of hydrology from the viewpoint of the practicing engineers in the arid section of the United States, together with an outline of water law and its administration as it has developed in the arid states. The volume is a result of the combined experience of two authors engaged in the engineering problems in the arid West over a period of forty years. The material presented, however, is of universal application.

The volume contains a vast amount of statistical material in engineering studies which has been developed or has appeared in different publications of the United States Geological Survey (United States Geological Survey Water Supply Papers and Professional Reports); in reports of the Federal Power Commission; in the Monthly Weather Review of the United States Weather Bureau; in the publications of the Office of Experiment Stations and of the Bureau of Roads and Rural Engineering of the U. S. Department of Agriculture; in the publications of Agricultural Colleges and Experiment Stations of the various Western States; in the publications of the American Society of Civil Engineers; of the United States Bureau of Reclamation; and in such periodicals as Engineering News-Record; Engineering and Contracting; and Western Construction News.

Each chapter is followed by a very rich bibliography.

The volume begins by a brief history of the use of water and irrigation by the Indians, by the Spanish, and by the Mormons and presents irrigation by the United States from its earliest beginnings down to date.

Climatology, the deposition of precipitation, evaporation, transpiration, deep percolation, and stream flow and run-off have been presented by much statistical data for various locations throughout the Western United States. Intensity of precipitation and flood frequency records and application to engineering problems are discussed.

Upon the much discussed subject of cyclic variations in rainfall and other climatic factors, the author states:

"There is much evidence of oscillations in climate extending over a long period of time ranging from several to a thousand or more years. There are no exact meteorological data to confirm this, but there exist scattered observations and historical references to climate and occurrences which result from climatic changes, indicating that these oscillations have occurred in the historic past. In addition to this, there is the testimony of the big trees of California, with variations in size of annual growth rings of these trees showing that during the past 3,000 to 3,500 years there have been climatic variations of considerable magnitude extending over several hundred years."

Methods to be used in supplying missing rainfall, run-off, or other climatic data are presented and specific problems worked out.

In certain Western streams where appropriations of surface run-off have an effect upon percolation of water which would otherwise replenish ground water,

the authors have presented actual studies which have been made by the Division of Water Rights of California, State Department of Public Works, showing the results of several years study of relationship between flood flow and percolation into the ground and the alluvial valleys traversed by such streams during flood discharge. The control of floods by surface and ground-water storage is presented by detailed study upon several rivers in California. Methods of forecasting stream flow from rainfall records and snow surveys as practiced by public and private water and power corporations in the West is presented.

The water works operator unfamiliar with matters of water rights will find the chapter upon "Water Rights in Surface Streams," including discussion of riparian and appropriative rights, as followed by the courts in several states of much interest and value. Provisions of statutes in several Western states are also presented.

Determination of available water supply from various drainage areas and discussion of the economic development of stream systems is given by working out actual problems which have been studied. Occurrence of ground water, methods of determining available water supply, and more efficient methods of development are included, the problem of determining the safe yield of underground storage water reservoirs being one of great importance throughout much of the arid West. The power capacity of streams is studied and problems of joint use of reservoirs for flood control and water supply are presented in very complete studies made by the Division of Engineering and Irrigation, California State Department of Public Works. Administration of streams by appointment of water masters acting under court decisions and voluntary agreements in order to make available the greatest safe yield from a given stream system are discussed. The methods of administration in general use in the several states are pointed out.

Valuation and Earning Power of Water Rights constitutes an interesting chapter.

The final chapter is upon quality of water and discusses both the effect of geological formations upon the water and the effect of such impurities in the water upon domestic, irrigation, and industrial use.

The volume contains such a large amount of statistical data upon the field covered in its pages and presents so many engineering problems and their solution as typical examples, followed by a very full bibliography, that it is difficult to more than indicate the nature of its contents.

The volume should be of great value to students of water supply in technical colleges, engineers, attorneys, bankers and public officials in the Western states who are interested in problems of water development. The volume is also of much interest to the many engineers and executives in the Eastern United States who are finding the problem of available water supply one requiring most careful assembly of data, study, and analysis.—*S. B. Morris.*